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A POTTER AT WORK

by
ANSARI Z. D.

In an archaeological excavation of an ancient site, the largest number among antiquities are the earthen vessels and their broken sherds. Their survival to this day, inspite of their lying under several feet thick habitational deposits of centuries, without affecting the shapes, colour etc., show their durability when campared with other antiquities except the stone artifacts. The reason for their durability is due to the changes that have taken place in the composition of the clay when it is baked. Clay once baked in fire, retains its form and colour for centuries.

Ancient pottery, besides the characteristic shapes and forms, presents many other problems for study, e.g. the clay used for making the pottery, the methods of shaping the clay, materials used for surface finishes, colours used for painting designs, tools used at different stages of manufacture and the methods of firing. To understand these problems mentioned above, a special study was made with a local potter,[1] who still practises his art without the help of modern equipments of a complicated nature.

It is hoped that this discussion will be helpful in the understanding of some of the problems of ancient pottery.

The process of pottery making may be divided roughly into the following stages :

I. PREPARATION OF CLAY.
- Selecting the clay.
- Levigation.
- Treading.
- Kneading.

II. FASHIONING OF VESSELS.
- *Handmade*
- Coiling.
- Building.
- Moulding.
- Beating.
- Scraping.
- *Wheel-made*
- Rotating wheel.
- Tournette.

III. SOME SPECIAL TECHNIQUES OF POTTERY MAKING

IV. SURFACE TREATMENTS.
- Smoothing.
- Wash.
- Slip.
- Burnishing.
- Polishing.
- Glazing.

V. DECORATIONS
- Painted.
- Incised.
- Applique.
- Embossed.
- Moulded.
- Stamped.

VI. FIRING
- Open kiln.
- Closed kiln.

VII. POST FIRING TREATMENTS

1 Mr. SUMER SIDDIQUE, a hereditary potter from Kutch, now residing in Poona.

I PREPARATION OF CLAY

Clay is the main substance on which the potter's success in making good vessels depends. When the clay is devoid of impurities and possesses good plasticity, the pots made from it are of a better quality. There are other factors also which govern the quality of the finished products, which will be described later.

Potters generally obtain the clay from the dry beds of lakes or from the deposits on the river banks etc. The clay brought from these sources is not used in its natural state for making vessels but is made to undergo several stages of cleaning and then it gets ready for use. These, as employed by Mr. SUMER, are as follows.

LEVIGATION :

When the clay is brought from its source, it is cleared of impurities like pieces of stones, pebbles etc. by pounding the lumps of clay into powder and then sifting it with a sieve. It is then put in a pit (measuring about 4′ in diameter), specially dug to a depth of about 5′ and then water is poured over it (Plate—I, a-c). In this pit, the mixture of water and clay is well stirred with a stick or by trampling with feet (Plate-I, d,e). Then this liquid clay is taken out of the pit and *sifted* into a shallow levigation tank, which is made on the ground surface by raising the side walls only (Plate-I, *f*). Before pouring the solution in it, finely sieved ash is spread over the bottom of the levigation tank, which helps in the separation of the clay . In that tank the liquid clay is allowed to remain till the excess water is evaporated and the clay develops cracks while it is wet (Plate-I, g). The time required for this process depends upon the weather conditions. Summer is the best time. It is then taken out from the tank in small blocks (Plate-I, h) and stored by making a heap under the shadow of a tree or a roof and covered with wet rags. The clay in the levigation tank is more fine at the edges and the upper-half of the deposited clay, while at the point where the sieve was kept, the clay is comparatively coarse.

TREADING :

When clay is needed for making vessels, some portion from the heap, which is stored under the shade, is cut by hand or a piece of wood in vertical slices, so as to get finer as well as coarser clay evenly and then it is treaded on a rag by adding a little water as required for softening it (Plate-I, i.). The rag is used so that the impurities may not get into the clay while treading. No nonplastic material like fine sand etc., is added, as it is already present in the clay. Some potters mix the dung of horses, asses etc., as a binding material.

KNEADING :

After treading the clay fully, it is deposited in a big lump and then small lumps are taken out from it and kneaded on a rag by hands as the dough is kneaded. While doing it even the smallest piece of impurity is removed. Occasionally hands are rubbed with finely sieved ash, so that the clay may not stick to hands. The kneaded clay is kept under a wet rag so that it may not get dry and its consistency may not get reduced. Now the clay is ready in the form of small lumps for shaping the vessels.

Plasticity and fineness of clays differ from place to place. Hence the process of preparing the clay also differs in different places. According to a potter in Poona, the clay in Kutch does not require the elaborate process of levigation, as good quality of clay is available naturally and is used without levigation. The processes of soaking, treading and kneading of clay are essential stages for any type of clay for making it suitable for shaping vessels.

II. SHAPING OF VESSELS :

Different methods are explained below.

COILING METHOD :

The wall of the vessel is built by superimposing the rolled clay in position. The construction starts by preparing the base which may be flat, rounded, conical etc. For a flat base, a disc is made on a flat surface of a stone slab, or wooden plank by dabbing the clay first by hands and then flattening it with a dabber. A groove is made along the edge of the disc so as to fix the first roll of clay to start with. When a rounded or conical base is desired, it is made by hand or by placing a disc sheet of clay in a concave bottom of a broken pot, and then kept in a basket with sufficient padding having the same shape. For placing the coils, the potter himself goes round and fixes the coils in position. Construction of a vessel by coiling is done only when big storage vessels of thick wall are desired. The complete construction is not done at the same time, but in stages. When the lower portion gets a little dry, the work of coiling is resumed. If it is done continuously there is a likelihood of the walls collapsing. Bigger pots are not made by one single roll of clay but rolls of small lengths are added. Their ends are flattened so that the next piece of roll may overlap. When small pots are made sometimes coiling is done in a spiral way. On beating, it is difficult to make out the way they are built.

When the vessels are leather-hard they are beaten with a flat wooden mallet from outside with one hand and supported by an anvil on the inner side by the other hand. The beating is done in such a manner that the coils get mixed up and even thin traces are eliminated. The process of beating further increases the cohesion between the coils.

TOOLS :

The mallet is generally a rectangular or oval shaped flat wooden piece with a handle. The tool is made from one single piece of hard wood. The anvil is an oblate shaped piece with a knob handle. It is generally of stone, but sometimes also made of baked clay. (Fig. 1)

BUILDING METHOD :

The walls of a vessel are raised by adding small flat pieces of clay and they are fixed in position by pressing with both the hands. The method of making the base is similar as described in coiling method. The entire shape of the vessel is not made at the same time but it is made at short intervals so that the lower portion gets some strength due to drying. When the pot is leather hard, it is beaten to the desired shape, as described above. Similar tools are employed for the purpose.

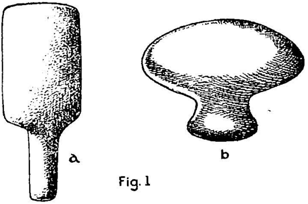

Fig. 1

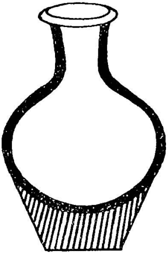

Fig. 2

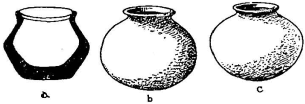

Fig. 3

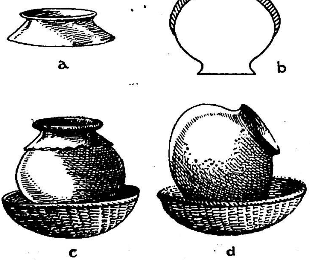

Fig. 4

MOULDING METHOD :

Some potters use moulds for moulding different parts of vessels. Bowls with relief decorations are also made in moulds.

These moulds are generally bowls in which a flat sheet of clay is placed on the inner side and the excess clay is removed by trimming. The clay is then pressed in position on all sides and smoothened with a piece of wet cloth. Care is taken to smear the inner surface of the mould with finely sieved ash, so that the moulded piece may come out easily when it is dry. Shrinkage depends upon the texture of clay. It varies from place to place. If needed the upper body or shoulder portion of the vessel is also prepared in a similar way in another mould which is provided with a hole for attaching a neck later on. These two moulded pieces are then attached by wetting the edges by applying some levigated clay and smeared from both sides. The neck is not made in any mould but is made on wheel by adding a thick ring on the opening and then the neck is made from it.

Potters from Navda Toli (Madhya Bharat) make their globular pots by moulding the lower portion on the convex base of an earthen pot, while the rim and the neck is turned on the wheel. When both the pieces get leather-hard they are joined together and beaten with the mallet and dabber to the desired shape.

A mould of hemispherical shape was discovered in the excavations at Navda Toli (1958-59). It has a thick slip on the outer surface while the inner side is without it. The lower portions of some pots fit in with that mould. On examining the lower parts of these pots it appears that they are moulded and later on the upper body and the neck are added.[2]

BEATING METHOD :

The tools used for shaping the pot by beating are shown in Fig. 1. By the process of beating, clay expands and the required shape is given to the pot.

To begin with, a small rough shape of pot is made on wheel or by hand, with thick wall so that it could be made thin by beating to a big size. It is possible only when the pot is dried to leather hard condition. While beating, the mallet and the dabber are dipped in water when the potter finds that the clay is getting harder. Occasionally finely sieved ash is spread over the portion which is under the process of beating.

The process of beating is very essential for making big pots for which rounded bases are needed that are difficult to make on a rotating wheel.

SCRAPING METHOD :

We have already seen that rounded base etc. are made by beating process, but it must be remembered that in such cases the necks are wide enough to put the hand with the dabber to give support from the inner side. Scraping is a method of removing the excess clay from the pots for thinning the wall and the base. The rounded base is very difficult to make on wheel, so they are shaped by scraping.

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2 Complete processs will be described under 'Technique of Shaping.'

Rounded base, on pots with narrow neck is made by scraping, as the hand cannot be put in the pot to support the base with the anvil if beating is intended. Hence in such cases scraping method solves the problem.

When a pot with a globular body and narrow neck is intended, first it is made on a wheel of a different shape. The desired inner side is shaped when it is on wheel, while the outline is different (Fig. 2a). When it becomes leather hard it is strong enough for handling. Then the extra clay (shown by shaded lines in Fig. 2a) is scraped either by free hand or by mounting the pot upside down on a rotating wheel.

Examples of scraped bases have been noticed on pots, with narrow neck and rounded base, and on casinated bowls (Fig. 2) from the excavations at Navda Toli (1958-59). These pots bear the marks of free hand scraping on the bases.

Some potters make the entire vessel by scooping from a solid lump of clay.[3]

ROTATING WHEEL :

A rotating wheel is like a cart-wheel, either solid or spoked. Solid wheels are made of circular flat stone or clay. The stone wheels are about 2″ thick and a hollow piece of agate is fixed at its centre. The terracotta wheels have spokes fixed to a thick circular wooden disc, while the rim is thick and is made of clay. In the centre of the solid circular disc, a hollow agate piece is fixed. These two types of wheels rotate on a pivot of hard wood which is generally fixed in the centre of a heavy flat stone. The wooden pivot is made from the core of a very hard wood either of a ' tamarind ' tree or of a ' babool ' tree.

To rotate the wheel, its centre is kept, very gently, on the pivot. Then the wheel is turned first by hand and then by putting a stick in a small hole (specially made in the rim) it is turned with anticlockwise movements and then the wheel gets momentum. The present potter's experience shows that spoked-wheel rotates faster than other types of wheels and requires comparatively less strength than is required for solid wheels, especially of stone. But solid wheel keeps its momentum for a longer time, though more strength is required to give momentum to it.

When the wheel is rotating, some prepared clay is applied at the centre of the wheel. This serves as the base for the clay to be fixed later, on it. Then some prepared lumps of clay are put one above the other and a cone is prepared by both the hands. The pot of required form is shaped on the top of a cone by the manipulation of fingers. When the pot is completely shaped it is cut at the base of the pot and then removed from the cone and kept on a plank of wood for drying in the sun. Then they are fired in an open kiln.

TOURNETTE :

Tournette, also called turn-table, is a primitive type of wheel. This is a concave dish which is constantly turned by hand and it rests on one inverted bowl

3 AIYAPPAN, A., ' Hand-made Pottery to the Urali Kurumbar of Wynad, ' *Bulletin of the Rama Varma Research Institute*, Vol. VIII, Part II, Trichur, Cochin State, 1940, pp. 88-91.

having convex base, serving as a pivot for the dish. This type of device for making dishes, bowls etc. is still in use in some parts of South India.[4]

III SPECIAL TECHNIQUES :

It has been observed that different shapes are given to vessels by the manipulation of fingers, when the vessels are turned on a rotating wheel. While working on such a wheel, the potter has the advantage of having both the hands free for shaping. The technique of shaping certain vessels differ from potter to potter. The plasticity of clay and the technique of an individual potter have great influence on the shapes and the finish of the vessels.

Vessels shown in Fig. 3a-b-c are made in the following way :

TURNING :

First a pot with a thick body (Fig. 3a) is turned on a wheel and then it is removed from the wheel by pressing the fingers at its base or with a string. At the time of removing the pot from the top of the clay cone, the wheel is slowed down by pressing the palm at the rim of the rotating wheel.

BEATING :

When the pot is dry to leather hard condition, it is beaten with a dabber and mallet (Fig.1). The dabber is held in one hand to give support while beating and it serves as an anvil on the inner side, and beating is done with a mallet at the point where the dabber has supported from underneath. The beating is done in such a manner as to spread the clay to the required shape. During the process of beating, the potter occasionally dips his dabber and mallet in water to moisten the clay. If the clay remains wet at some places, finely sieved ash is spread over the portion so that the clay may not stick to the mallet.

While beating, the pot is rested between the feet.

BURNISHING :

When the pots are dry, they are rubbed by putting several strings of a long necklace of big glass-beads, locally called '*mantha*', round the neck of the pot. While rubbing, the pot is kept on a ring of soft dry grass. Only the portion below the neck is rubbed while the base is left out. Sometimes, while rubbing, some oil is also applied. This process is called " burnishing ".

Similar pots as shown in Fig. 3 are made in a different way at Navda Toli. There such pots are made in two parts.

First the rim is made on a wheel (Fig. 4a) and removed from the wheel by cutting it with a string. The lower body is made by placing a thick circular sheet of clay on the convex base of a pot (Fig. 4b). Before putting it, finely sieved ash is spread over the convex surface. When both the portions get leather hard, the piece resting on the convex base is removed and kept in a basket (Fig. 4c), and beaten slightly to bring the two ends closer, and then the rim portion is attached over it (Fig. 4c) and the joint is fixed by rapid beating with the mallet and the

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4 ALLCHIN, F. R., 'Poor men's Thalis : a Deccan potter's technique', *S.O.A.S.*, Vol. XXII, Part 2, p. 251, London, 1959.

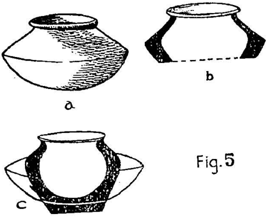


Fig. 5

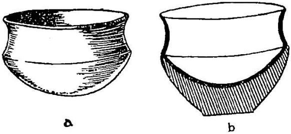


Fig. 6

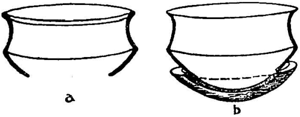


Fig. 7

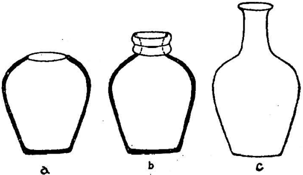
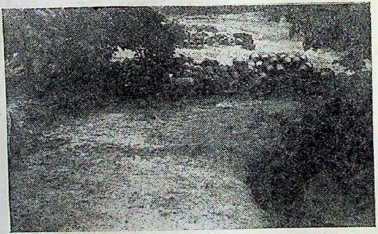
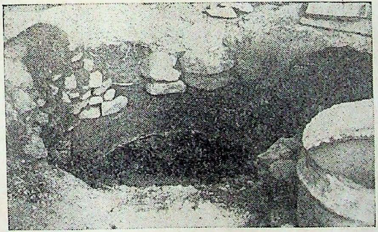
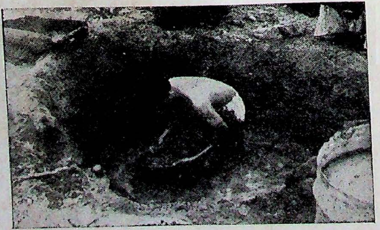
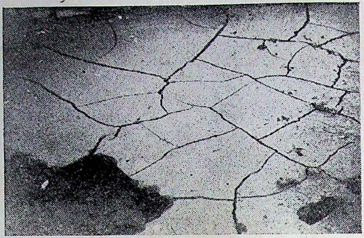


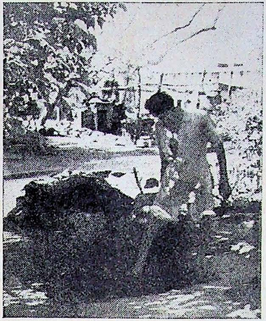
Fig. 8

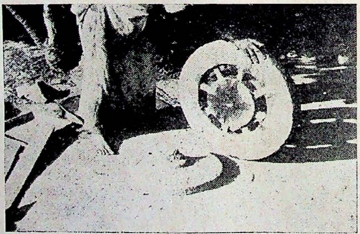


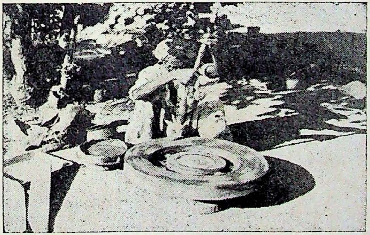


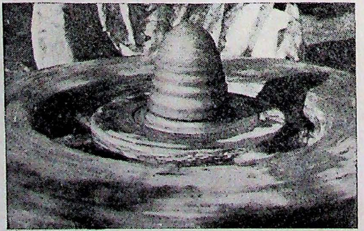


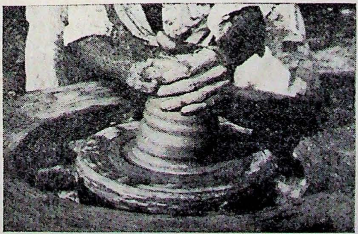


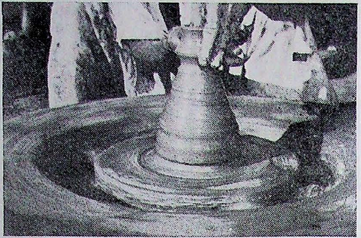


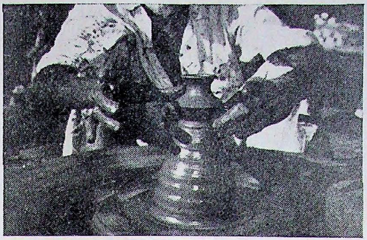


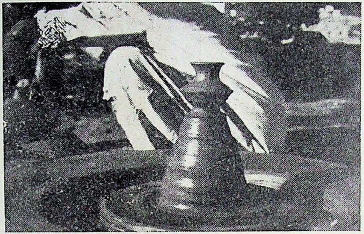












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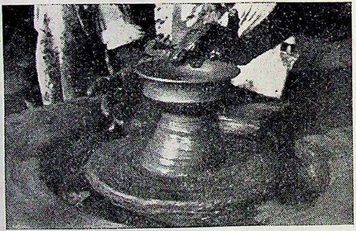
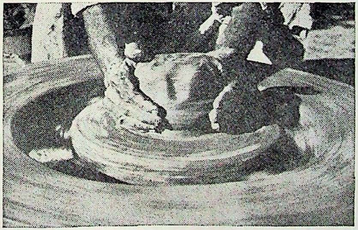
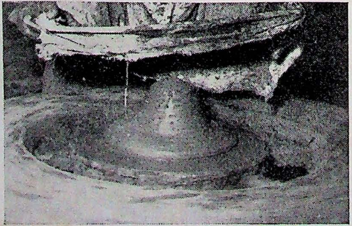
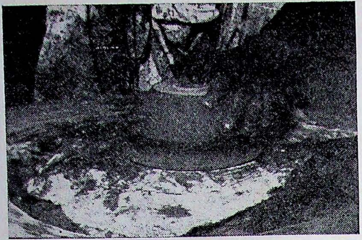
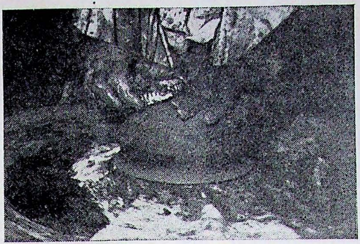










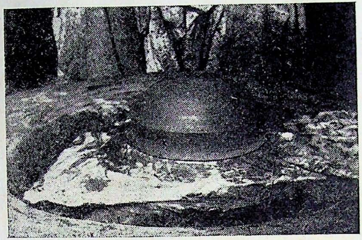
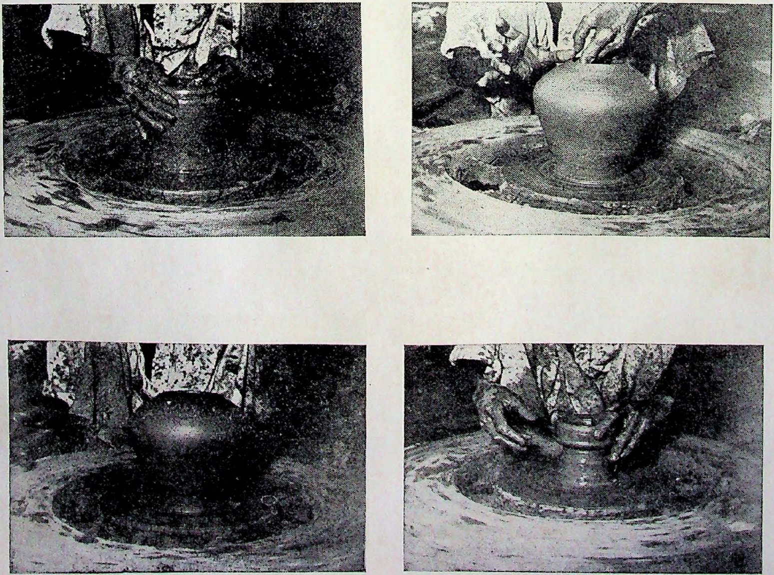
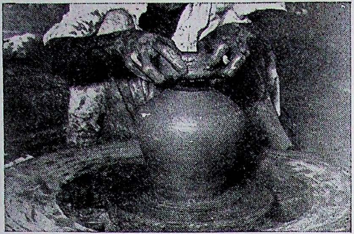
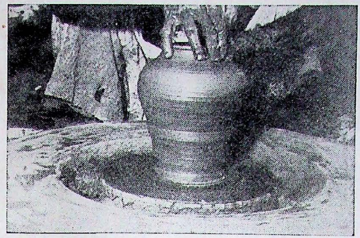
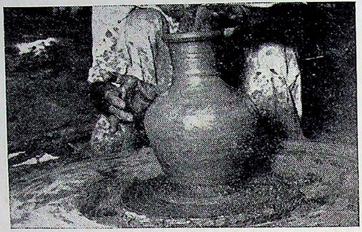


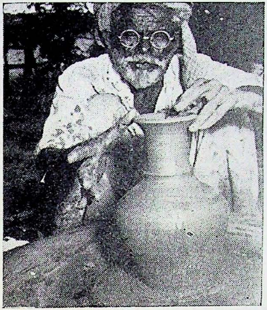
PLATE IV











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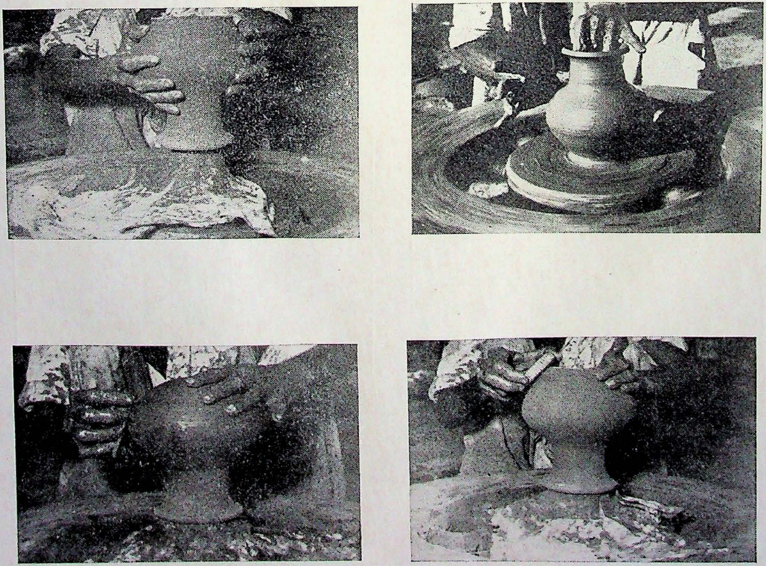

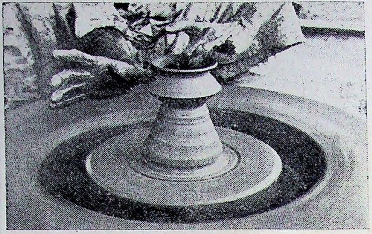

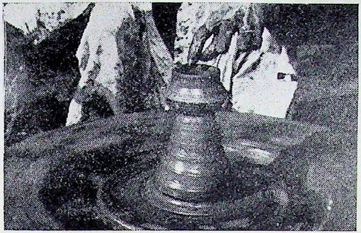

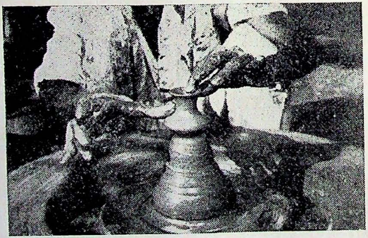

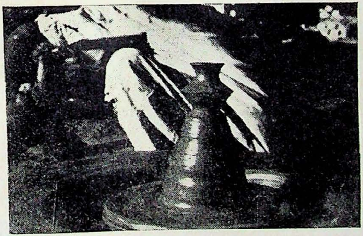

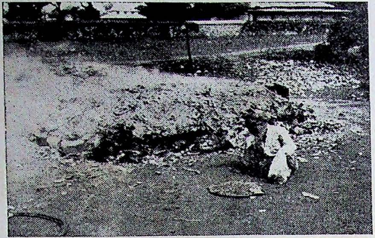

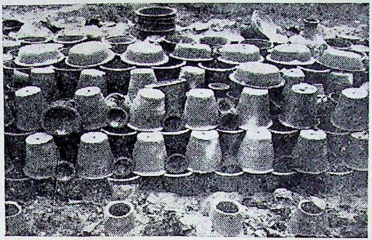

dabber. Slowly and at intervals, the beating is continued till the required shape is achieved. Burnishing is done in a similar way as described earlier. The beating is done by keeping the leather hard pot in a basket containing grass padding (Fig. 4d.).

The beating process, generally gives a rounded base because the dabber used for giving the support from the inner-side has a convex surface. When a flat base is desired, a flat topped dabber and mallet are used.

During the process of beating, if the potter finds that there is excess clay, then to reduce it, it is scraped from its surface by a sharp instrument and again the beating is resumed. The beating is done so efficiently that no marks of beating are left, especially on the outer surface.

A carinated pot with rounded base (Fig. 5a) is made in many ways. A pot of approximately globular shape (Fig. 5c-shaded) is turned on the wheel and when it is in leather hard state, it is beaten to a carinated shape with rounded base. Sometimes only half the pot upto the carination (Fig. 5b) is made on wheel and when it is leather hard, the portion below the carination is beaten so as to bring both the ends together. If the clay falls short of requirements, it is added as a flat disc and the pot is completed.

A concave carinated bowl with rounded base (Fig. 6a) is first turned on wheel with concave sides, rounded bottom, and below the carination it is made tapering (Fig. 6a, Pl. IIIa-b). When it is leather hard, it is again put on the wheel in an inverted position, and the excess clay is scooped out with some sharp instrument and a rounded bottom is shaped. Sometimes scraping is done by free hand, without putting it on wheel.

The process of scraping is as follows :

A small clay cone of the size to fit in the mouth of bowl is shaped on the wheel (Pl. IIIc), then it is covered with a piece of cloth (Pl. IIId) so that the wet clay of the cone may not stick to the bowl. After that, the bowl is kept inverted on it (Pl.IIIe) and pressed down (Pl.IIIf) so that it may not move while scraping.

The scraping is done with a sharp instrument (Pl.IIIg) and in order to remove the scraping marks, a piece of cloth dipped in fine liquid clay is moved over it (Pl. IIIh) so as to make the surface smooth (Pl.IIIi).

We have already seen that the base was made by scraping, either by mounting on the wheel or by free hand method. There is another way of making a concave carinated bowl with rounded base. When on wheel, it is cut below the carination (Fig. 7a). The base is made in a shallow concave saucer. After both had dried a little, the wheel-turned portion is kept on the base when it is already in the mould (Fig. 7b) and the joint portion is pressed in position. When the bowl is in leather hard condition, the excess clay of the joint is scraped on the outer-side by free hand scraping.

The bowls (Fig. 6a) from the excavations at Navda Toli 1958-59 and from the excavations at Nevasa 1959-60 (Dist. Ahmednagar) show techniques similar to those described above.

A pot with narrow high neck is made in two parts. First the body is made on wheel (Pl.IVa), and removed from it. When it becomes leather—hard, a clay ring is made on the wheel (Pl.IVg) and then after removing it from the wheel is kept aside. Again the leather—hard pot is mounted on the wheel and the clay ring is placed on its opening (Pl.IVh) and luted (Pl.IVi) to the body. With that ring the neck is drawn up (Pl.IVj-m) and the pot is completed. The neck so fixed could be made very narrow if needed.

A narrow and high-necked pot with rounded base and globular body (Fig. 9a) is first made on wheel with rounded bottom and disc base (Fig. 9b & Pl. Va-b). When it is in leather—hard condition, it is mounted again on the wheel. For mounting, a cone of wet clay is made at the centre of the wheel and then it is covered with a piece of cloth and pressed against it. Before covering the cloth on the cone it is tested (Pl.Vb.-i) whether it would fit in the mouth of the pot. After mounting the pot the round base is made by scraping the excess clay. Then the scraped surface is smoothened by the smooth back of a bamboo piece and fine liquid clay is smeared over it.

It may be questioned as to why the neck of this pot is not attached later on as it was done to the pot previously described (Fig. 8) though both have long narrow necks ? It is because by the time the neck, if attached later on, gets leather—hard, the base would have become too hard for the scraping. But it is not necessary that the base should be scraped on the wheel only, as pots of similar form from Navda Toli indicate free-hand scraping on the rounded base.

A carinated pot with rounded base, flaring rim and a spout (Fig. 10a) is first made on a wheel (Pl.VIa-e &) with a disc base (Fig. 10b) and when it is dry to leather—hard state, it is mounted on the wheel in an inverted position, in a similar fashion as it was done in the case of carinated bowl (Pl.IIIg,h) and a high necked pot (Pl.Vc-e.), and the base is scraped to make it round. The bottom has already become concave when the pot was on the wheel (Fig. 10b - shown in dotted lines). Sometimes free hand scraping is also done. This technique is used when pots of small sizes are intended. For bigger size pots, they are turned on wheel, and then cut without its bottom and by doing so, a hole is left in the bottom (Fig. 10c.). When it is leather—hard, the hole in the bottom is closed by beating the surrounding clay, which is sufficient to fill it up. It should be noted that only the lowermost portion is beaten. The spout is also made on wheel and kept ready. When the pot and the spout are slightly hard, a hole is pierced on the shoulder and the spout is fixed by putting it through, and is luted by applying some wet clay on the outer surface of the pot. When the pots have necks wide enough to put the hand inside, then the spout is luted from the inner side also, but in the case of narrow-necked pot, the spout is luted from the outer side only.

A large number of pots from Nevasa, having similar form were found to have been made with the technique as described above. The striation marks, on the inner-side, near the base are visible while they are absent on the surface of the bottom, and on the outer side, no marks, either of scraping or of striation, are visible. The base when compared with other parts of the pot are thin. The thinness seems to be the effect of beating.

Miniature pots with very narrow long-necks and rounded base are made on wheel, first with the disc bases (Fig. 11-a-b & Pl. a-j-), which are scraped to make them rounded when they are in semi-dry state. Scraping is done free-hand. The rounded bottoms are made when they are on the wheel (shown in dotted lines, Fig. 11a-b). It is interesting to note that necks are so narrow that it is difficult to put the finger through them. They are made by first putting a finger inside the neck and as the inner finger is moved up, the portion below the finger is gently pressed by the thumb from the outer side (Pl. VII-b). When the pots are dry they shrink and the necks became narrower.

VI SURFACE FINISHING

SMOOTHING :

When the vessel is completely shaped and is still on the wheel, the surface is smoothened by means of a piece of cloth dipped in a thick liquid of fine clay. This fine clay accumulates on the fingers of the potter and is collected in the vessel containing water, which he keeps by his side, as he has to dip his hands so often while shaping the vessels.

BURNISHING :

When a pot is in leather—hard condition, it is rubbed generally with a necklace of glass beads, which is locally called '*mantha*'. It is also rubbed with a polished pebble or any other object having smooth surface like pieces of agate or with a cowri shell. When a pot is burnished, small cavities get filled up and a smooth surface is formed. A pot treated in this manner gets a shining surface after it is fired.

WASH :

When an unsmoothened or smoothened vessel is completely dry, its surface or surfaces (inner and outer) are smeared with a thin liquid of ' red ochre ' or with any other clay of different colour. After the vessel is fired, the surfaces become red matt.

SLIP :

Slip is a very thick paste of very fine clay. It is the same thick clay which is collected on the potter's hand while turning the vessels on wheel and very often he removes it and collects it in a vessel to use it as a slip when required. Sometimes it is made from a clay other than the one used for making the vessels. When a red slip is desired, a thick paste of red haematite is applied over the leather hard surface. When the slip gets slightly dry it is rubbed with a piece of woollen cloth. Longer the time it is rubbed, the more smooth and bright will be the surface after firing. Many pieces of red haematite showing rubbing marks have been discovered in the excavations at Nevasa (1959-60) in the Chalcolithic period.

Slip serves as a coating to cover the original surface of the vessel and fills the cavities and makes the surfaces of the vessel smooth.

A thick slip is profusely used on the pottery found in the excavations at Navda Toli (1958-59).

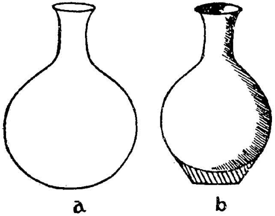

Fig. 9

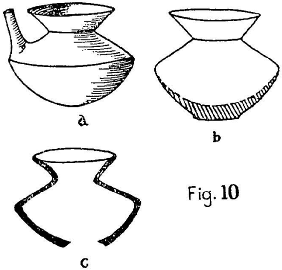

Fig. 10

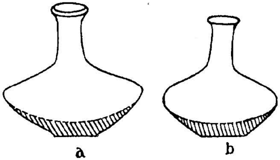

Fig. 11

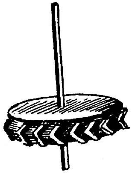

Fig. 12

Fig. 13

Without any kind of rubbing, the surfaces remain matt. Lustre is the result of rubbing the surfaces for a longer time with or without the application of a slip.

V Decoration

Painted :

Different designs in black—on—red surface are painted with a solution made by rubbing a piece of dark-brown haematite. The brush is made from a bamboo piece, beaten at one end to make it fibrous.

When the pot has been coated with a wash or slip as desired, and while it still is in leather—hard condition, the designs are painted on it when the surface is still wet. When the pot is fired the painting appears black on a red surface.

For painting bands on the pot, it is mounted on the rotating wheel (Pl. VIII, b,c,h,i). Before mounting the pot, a clay ring is made at the centre of the wheel and then it is covered with cloth (Pl. VIII, a,g). The speed of the wheel is slowed down before starting the painting. The bamboo brush is dipped in the haematite liquid and is held at the point where the band is desired (Pl. VIII, b,c,h,i). Other details of the design are painted by placing the pot on a convex surface, generally on an inverted bowl with convex base, and one hand is placed on the mouth of the pot (Pl. VIII, f,j) to keep it in position and also for turning the pot when needed.

Sometimes the designs are painted by holding the pot in another hand instead of keeping it on an inverted bowl.

Incised :

Decoration by incising with a hard point is done only when the pot is in a leather hard condition. Parallel bands are incised by mounting the pot on the wheel in a similar way as it is done while painting. Wavy lines are incised by free hand and not on wheel. Continuous designs e.g. chevrons etc. are executed by a small wooden wheel or a T. C. wheel which is mounted at one end of a stick (Fig. 12) and the design is cut in relief on its circumference.

Appliqe :

Applique decorations are generally in relief. Small casts of flowers etc. are made separately and when the pot and the casts get slightly dry, the surface of the pot is scratched a little and some fine liquid clay is applied over the scratched portion. Then the moulded flower is fixed in position. The fine clay, here, serves as a sticking medium.

Finger tip design or pinched designs (Fig. 13) are executed in the following way.

When the pot is still under preparation on wheel, a broad conical band is made at the desired place for making the finger tip decoration. For a pinched decoration a flat raised band is made. When the pot is removed from the wheel, the decorations are executed.

MOULDED :

Finger tip decorations are done by pressing the thumb or any other finger. Pinched decoration is done by pinching the flat band at intervals with the thumb and the index finger.

Relief decoration can be made also by moulding the vessels or a part of it by pressing the prepared clay in a negative mould.

EMBOSSED DECORATIONS :

Small tablets of clay or wood having negative or positive designs are impressed on the pot when it is slightly dry. While embossing the tablets, the under-side of it is supported by a dabber.

VI FIRING

Vessels are generally fired on an open ground. First a layer of dry leaves or dry sticks is spread on the ground and the pots are arranged in layers (Pl. X, 1-3). Then broken pots are arranged along the edges of the layers of pots. These broken pots serve as a wall for the kiln. The top is then covered first with broad pans, sometimes they are specially made for this very purpose. Two necks of broken pots are kept on the top, on two sides of the kiln (Pl. X, 5, marked ' x '), to serve as chimneys. Nowadays some potters use tin sheets to cover the top (Pl. X, 4-7). Then a thick layer of dry-leaves (Pl.X, 8) is spread on the top of the cover, which is again covered by ash or earth and pressed (Pl. X, 9-11). Some openings are kept at the bottom as air passages. Through these air passages the fire is lighted. When the entire fuel gets burnt, which is detected by the absence of smoke coming through the chimneys, the pots are supposed to have been baked. When the potter feels that the fuel in the kiln is insufficient it is added through the air passages.

The quantity of fuel necessary for a certain number of pots, depends upon the quality of fuel, and the judgment of the potter.

When black surfaces are needed for the pots, the kin doors (air passages) provided at the base, and the chimneys on the top are closed, when the entire fuel in the kiln has burnt. Before closing the passages some more fuel is thrown in the kiln through the air passages so that smoke may be formed in the kiln. For baking bigger pots, some fuel, like husk or dry leaves is put inside it.

VII POST FIRING TREATMENT :

Sometimes a slip of red ochre is applied after the firing, also painting in different colours is executed on baked pots, which are at present used in marriage ceremonies.

THE ORIGIN OF TĀRĀ

by
DHAVALIKAR M. K.

The Mahayana school of Buddhism is responsible for the development of the cult of Bodhisattvas and making the Buddhist pantheon more complex by introducing into it a good number of gods and goddesses among whom Tārā, the female counterpart of Avalokiteśvara, is the most important. She holds the same position which the goddess Durgā occupies in the Hindu pantheon and figures as the female counterpart or *śakti* of Avalokiteśvara just as Durgā is the *śakti* of Śiva. Tārā is represented as the mother of the Buddhas as well as of the Bodhisattvas and she appears to be practically independent. From her sculptural representations her worship appears to have been quite wide-spread.

As her very name would show Tārā (from the Sanskrit root *tṛ*, 'to swim across') is primarily the saviouress or deliveress who carries the worshippers across the waters or troubles. The names by which she is known in Tibet, China, Korea and Japan all give the same meaning. She is the deity who carries the worshippers across the waters and is therefore to be invoked when crossing flooded waters as she is said to be controlling navigation.

The exact date of the introduction of Tārā in the Buddhist pantheon is not known; she is believed to have had a hoary antiquity, but her sculptural representations begin to appear only from 6th Cent. A. D. and since then she has a wide distribution in time and space in India till the advent of the Muslim rule.

So far as the origin of Tārā is concerned the general opinion seems to be that she is essentially Buddhist in origin. HIRANANDA SASTRI in his "*Origin and Cult of Tārā*" has sought to prove her Buddhist origin. He states that she is practically unknown to the earlier Brahmanical books where, if any distinct personality is mentioned under the name of Tārā, it seems more Buddhist than Brahmanical. He cites the relevant Tantric texts which show that the cult of Tara must have been Buddhist in its origin or, in other words, the Brahmanical mythology adopted it from the Buddhist pantheon. Moreover, the fact that the goddess is to be propitiated by *chīnāchāra* (i. e. the Chinese mode of worship) and that Akṣobhya is placed on her head lend support to the hypothesis of SASTRI that Tārā must have had a Buddhist origin.[2]

BHATTACHARYA, another authority on Buddhist iconography, compares the identity between the *dhyāna* of Tārā as given in the *Sādhana-māla* and the one in the *Tantrarahasya* of Brahmananda, who flourished in the 16th century, and in the *Tantrasāra* of Krishnananda. The similarity between the *dhyānas*-the Buddhist

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1 *M.A.S.I.*, No. 20, (Calcutta, 1925), pp. 12-13.

2 *Ibid.*

and the Hindu-which is undoubtedly striking, has led BHATTACHARYA to conclude that the concept of Tārā in the Hindu pantheon was borrowed from the Buddhists[3].

The problem of the place of origin of Tārā has also been examined by SASTRI. He dismisses the possibility of her origin in South India and infers from the literary evidence furnished by the Tantras that she originated in the north somewhere towards Ladakh. From Ladakh she travelled to Tibet and Nepal where she was a very popular deity and thence to India.[4]

Tārā seems to be unknown before the 5th Cent. A. D. as her sculptural representations are not found even in the late Gandhara art. The earliest images of Tārā are met with only in the Buddhist caves of Western India belonging to the 6th-7th Cent. A. D. and she appears to have become popular in the 7th-8th Cent. A. D. Moreover, it appears that the *śakti* worship was introduced in the Mahayana Buddhism sometime in the 6th Cent. A. D. From all this it can be inferred that the concept of Tārā was introduced about 5th Cent. A. D. and in 7th Cent. A. D. when the Tantric influence was at its zenith she was Brahmanized as the second *mahāvidyā* and became very popular not only in India but also in other countries.

The accepted theories regarding the origin of the cult of Tārā and the place and the date of her origin given above have been dealt with in greater detail by HIRANANDA SASTRI. As the validity of these statements was never before tested it can be safely assumed that they have been generally accepted. But if we critically examine ancient Brahmanical literature and examine the sculptural evidence at hand it will be found that the above theories are no longer tenable as the evidence literary and archaeological as well, runs counter to them.

The later Brahmanical literature, more particularly the Tantric, no doubt mentions the Hindu deity Tārā which, it is felt, appears to be more Buddhist than Hindu while in the early Brahmanical literature Tārā is mentioned as an epithet of Durgā; but Tārā, as a distinct divinity appears in the *Purāṇas*. The *Lalitopākhyāna* section of the *Brāhmaṇḍa Purāṇa* not only alludes to but also fully describes the goddess Tārā as a distinct Brahmanical deity which might have been worshipped by Hindus in the ancient past. It describes Tārā as a *mahāśakti* and is further called Tārāmbā or Tārā, the mother. She is represented as the chief of the countless boat-women (*śaktis* or *nāvikis*) controlling the navigation in the lake of nectar who can supress the flooded waters. She controls the rush of waters and is also the chief of those *śaktis* who navigate or guide the boats.[5]

Another *Purāṇa*, mentioning Tārā is the *Agni Purāṇa* which refers to her as *yoginī*.[6] The goddess Tārā of the *Purānas* is apparently not the same as that of the Tantric literature wherein she appears as a *mahāvidyā*, but Tārā of the Puranic literature may be the prototype of the Tārā of the Tantric literature.

All this goes to show that Tārā as a distinct divinity was known to the

[3] *Indian Buddhist Iconography*, (Calcutta, 1958), p. 190.

[4] *op.cit.*, pp. 15-16.

[5] Ch. 31, Vs. 12-18.

[6] Ch. 52.

Purāṇās and the concept of the deity was quite developed at the time of the composition of the *Brahmāṇḍa Purāṇa* which is regarded as one of the early *Purāṇas* for the account of the kings given in it ends with the Imperial Guptas and their contemporaries which could not have been the case had the *Purāṇa* in question been composed after the 5th Cent. A. D. Dr. HAZRA,| who has made a painstaking analysis of the different sections of the *Purāṇas* and has assigned the earliest and latest dates to them, ascribes the 3rd Cent. A. D. as the earliest and 5th Cent. A. D. as the latest date to the *Brahmāṇḍa Purāṇa*. He is of the opinion that it could not have been finally redacted before the 4th Cent. A. D.[7] This helps us to conclude that Tārā as a distinct deity of navigation had a definite place in the Hindu pantheon well before 5th Cent. A. D.[8] It is, however, enigmatic that no Brahmanical representation of Tārā as a deity of navigation has so far been found in the country.

The references to Tārā in the Buddhist literature are all of a later date, in no case earlier than 6th Cent. A. D. and those mentioning Tārā do not clearly connect her with navigation or waters. Moreover, her sculptural representations also do not occur before the 6th Cent. A. D. This implies that Tārā as a goddess was not known to the Buddhists before 5th Cent. A. D.[9] All this is indicative of the borrowal of the concept of Tārā by the Mahayana Buddhists from the Hindu pantheon. And it is quite reasonable to expect the Buddhists to borrow Hindu deities as a considerable number of Buddhist deities have had their origin in the Hindu pantheon. For instance, Kubera, Sarasvati etc. were taken in their original form while in many of the forms of Avalokitevaśra there are unmistakable traits of Brahmanical cult gods. This shows that those Hindu gods like Śiva, Brahmā and others whose cults were popular, were suitably incorporated in the Buddhist pantheon in order to attract to the Buddhist creed certain sections of the Hindu population. This process of borrowal was found advantageous as " the converts naturally carried into their religion much of their reverence for the old Hindu gods and found that the tradition offered them already embraced Indra, Brahmā and others of their former divinities. "

From the foregoing account it would not be wrong to infer that Tārā, the Hindu goddess of navigation was borrowed by the Buddhists and introduced into their pantheon. As Tārā, according to the descriptions in the *Purāṇas* was the Hindu deity of navigation she was probably worshipped and adored by those connected with maritime activity. Among these were possibly navigators, mariners and merchants engaged in sea-borne and river-borne trade, whose sole guide since antiquity is the *Pole Star* which, in all likelihood, might have suggested the appellation of the deity, Tārā, meaning thereby 'star'. Hence it is quite natural that the Buddhists desired to attract to their creed these classes of society which formed an important section of the populace particularly in coastal regions. And they perhaps achieved this by introducing Tārā in their pantheon. The Jainas probably

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7 *Studies in the Puranic Records on Hindu Rites and Customs*, (Dacca, 1940), p. 18 and p. 175.

8 J. N. BANERJEA, *Development of Hindu Iconography*, (Calcutta, 1956), pp. 540 ff.

9 A. GRUNWEDEL (Tr. by JAS. BURGESS), *Buddhist Art in India*, (London, 1901), p. 182.

borrowed the goddess from the Buddhists.[10]

Let us now examine the theory of the place of origin of Tārā. SASTRI,[11] as noted above, is of the opinion that the concept of Tārā originated and developed somewhere toward Ladakh and thence was introduced in North India (Magadha) through Tibet and Nepal. From Magadha it spread over rest of India. But this theory is not tenable in the absence of concrete evidence. For, if the concept of the deity originated and developed somewhere in Ladakh it is just reasonable to expect her earliest representations in that region or in Tibet or in Nepal. Surprisingly enough the earliest images of Tārā are not found either in Ladakh or in its adjacent territories but in Western India where she appears to have been received with the same reverence as Avalokiteśvara and was given equal rank and endowed with the same powers. From her sculptural representations in the Buddhist caves in Western India and Northern Deccan it appears that her worship was popular at Kanheri, Nasik, Ellora, Aurangabad and Ajanta.[12] They are all ascribable on stylistic grounds to Circa 6th-7th Cent. A. D. and as no image of a still earlier date has so far been found in any part of the country, they are probably the earliest representations of Tārā.[13] As already described, she was a deity of navigation and hence it is natural that her worship was widespread on the western coast of India which was humming with maritime activity. For, the trade of India with the Mediterranean world was carried on from the western coast. The merchants and mariners on the western coast invoked Tārā for protection and security in their undertaking and these people either individually or collectively caused to carve her images in the Buddhist caves in Western India. If the evidence at hand is any indication, they were the first to carve the images of Tārā. This leads us to surmise that Western India is probably the place of origin of Tārā and not Ladakh.

It may not be out of place to mention here the reverence with which Tārā was received in Western India. The earliest litany to Tārā is carved in Cave X at Ellora[14] and it places her on equal footing with Avalokiteśvara. A temple in

10 Sutara or Sutaraka is the *sasanadevi* attendant on Chandraprabha, the 8th *Jina*.

11 *op. cit.*, p. 21.

12 No image of Tara was so far found either in stone or in paint at Ajanta and this was therefore taken to suggest that her worship " was not popular with the Buddhists at Ajanta and cult might have belonged to a different sect ". (See R. SENGUPTA, " A Sculptural Representation of the Buddhist Litany to Tara at Ellora ", *Bulletin of the Prince of Wales Museum of Western India*, No. 5,1955-57, p. 13). However, the writer has recently noticed at Ajanta an image of Tara which is carved in a cell excavated in the right wall of the passage leading from Cave X to Cave XI. It is about 2′ high and is much weather-worn. The head is considerably damaged and the whole body has lost its relief features due to weathering. She is shown standing by the side of Padmapani on a full-blown lotus and holds a lotus-creeper in her left hand while the right hand, the fore-arm of which is broken, was probably held in the *abhaya-mudra* as can be inferred from its present position.

Stylistically the image in question compares favourably with that of Tara in the Cave VII at Aurangabad and can therefore be dated to Circa 6th-7th Cent. A. D. This is therefore the first and perhaps the only image of Tara at Ajanta.

13 SASTRI too agrees that these are by far the earliest representations of Tara. See o *op. cit.*, p. 19.

14 SENGUPTA, *op.cit.*

her honour was built in the Taranga Hill[15] in Gujarat which, though in ruins at present, still contains a huge image of Tārā datable to the 8th Cent. A. D. Still more interesting is an inscription of A. D. 1095-96 of the time of the Western Chalukyan king Tribhuvanamalla or Vikramaditya VI (1076-1126) in old Kanarese which was found near a ruined temple in the fort at Dambal (Dist. Dharwar, Mysore State).[16] It is carved below the figure of Tārā and records certain grants to the two viharas of the Buddha and Tārādevī respectively, the latter constructed by the Jaina *śresthī* Saṅgavayya of Lokkigu*ṇḍī*.

Last but not the least important is the similarity between Tārā and Pārvatī. In the early Brahmanical litérature Tārā is mentioned as one of the names of Pārvati, who is also called Durgā, the consort of śiva. Durgā is described in literature as the mother of all gods while Tārā in the Buddhist creed is also called the mother of all gods. Thus the introduction of Tārā in the Buddhist pantheon can be taken to be an attempt to have a powerful female deity in their own creed.

The litany to Tārā sculptured at Ellora is echoed in an epigraph from Dambal as noted above. The literary parallel of the same is found in the *Mārkaṇḍeya Purāṇa*[17] which is most interesting and significant and suggests that it is not impossible that Caṇḍī, who is worshipped by the Hindus for protection from the eight great dangers-*aṣṭamahābhayas*-also influenced in shaping Tārā as a protector from the same dangers.

The cult of Tārā spread rapidly beyond the frontiers of India[18] and the earlist dated image of the goddess outside India is in Java where an inscription (A.D. 778) recording the construction of a sanctuary of Tara, called Kalson Candī,[19] is found.

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15 Taranga, one of the Jaina *tirthas*, is situated among the hills in northern Gujarat. That it was a Buddhist *tirth* originally is amply demonstrated by the *Kumarapala*-charita of Somaprabhacharya (12th Cent. A. D.) where in the story of Khaputacharya we read of a king named Veni-Vatsaraja, probably a mythic personality. We are told in that work that he became a convert to Jainism and that he had originally built a temple of Tara and that town was called Tarapura. This is perhaps the one which is presently known as Tarana-mata temple, a rock-cut shrine in the Taranga Hills containing nine Buddhist images, many of which are now mutilated. The central figure in the group is that of Tara (See A. S. GADRE, "Buddhist Influence in Gujarat and Kathiawad ", *Journal of the Gujarat Research Society*, Vol. I, No. 4, *Bhagwanlal Indraji Commemmoration Vol.* Oct., 1939, pp. 66-67).

The Taranga Hills can be identified with the Tarangavati which is mentioned in an early Buddhist text *Mahamayuri*. The text contains a record of sacred Buddhist places along with their guardian *yaksas*. A *yaksa*, Sukhavaha by name, is mentioned as the guardian of Tarangavati. (See V. S. AGRAVALA, " Geographical Contents of *Mahamayuri* ", *JUPHS*, Vol. XV, Pt. ii, 1942, p. 28).

16 *IA.*, Vol. X, p. 185.

17 Ch. 89, Vs. 25-29.

18 SASTRI, *op. cit.*, p. 12.

19 The *Javanese Chronicles* relate that about 603 A. D. a ruler of Gujarat, forewarned of the coming destruction of his kingdom, started his son with 5000 followers, among whom were cultivators, artisans, writers, warriors and physicians in six large and a hundred small vessels for Java where they laid the foundation of a civilization that has given the world the magnificent sculptures of Borobudur (See R. K. MUKERJEE, *Indian Shipping*, 1957, p. 105, f.n.).

Now from the evidence discussed in the foregoing pages it can be said with reasonable amount of certitude that the cult of Tārā travelled to South-East Asia from Western India only. This may probably be due to the large scale migrations from the western coast of India to South-east Asia which were caused by the devastation by the Scythian tribes as also by the draughts in India during 6th Cent. A. D.

EXCAVATIONS IN THE PREHISTORIC CAVE SITES IN FRANCE

by

JOSHI R. V.

Of all the countries in the world France has the maximum number of well preserved prehistoric sites, which make it a classic region for prehistoric studies especially for the palaeolithic cultures. As is well-known several of the cultural terms used in prehistory for describing either technique or industries of the different stages of the Stone Age are derived from the names of the localities in France, where such things were first discovered. For example the terms like Abbevillian, Acheulian, Levallois (Lower Palaeolithic Cultures); Mousterian (Middle Palaeolithic Cultures); and Aurignacian, Perigordian, Magdalenian (Upper Palaeolithic Cultures) etc., are coined after the villages of the same names.

As in many other countries the Lower Palaeolithic sites in France also are mostly the open-air stations located on the river banks or at the foot of the hills. Some such sites, viz., those in the vicinity of the villages Levallois and St. Acheul are, however, on the verge of disappearance on account of modern expansion of the neighbouring town limits. But the most important sites in the country are of the Middle and Upper-Palaeolithic periods, which are invariably associated with the caves or rock-shelters. Such caves in limestone formations occur all over this country but their maximum concentration is seen in the river valleys, and hill ranges in southern and western France.

Except during the middle Acheulian, in Chellean and Early and Late Acheulian times of the lower Palaeolithic, somewhat warm climate prevailed in Europe and therefore, there was no pressing need for early man to move to a suitable shelter for protection against cold. In the following Middle Palaeolithic period the climate became very cold, and in the Mousterian times it was like an Arctic or Tundra climate, which forced the Mousterian people to occupy natural rock shelters and caves. For this very reason, open-air Mousterian sites are rare. In the Upper Palaeolithic the climate remained cold and man naturally continued living in the shelters.

The rock-shelter sites in France are thus very important, for, not only they contain stone industries of successive periods, but also human and animal skeletal remains. The sedimentary deposits in which these prehistoric relics occur throw considerable light on the climatic conditions that were prevailing at the time when such deposits were laid down as sealing layers over the cultural deposits.

Excavations at these archaeologically rich sites have to be done with the utmost care, for the deposits are usually very limited in thickness and extent. As the cave surface and walls are very irregular in shape the culture-bearing deposits

do not maintain any definite level. These deposits often contain minute objects like fragments of stone implements and their debitage, bones of tiny animals like rats, lizards, bone implements like fine needles, pins, etc., which require careful handling. Occasionally human skeletons are also encountered with which again necessitates proper care as is usually taken whenever such objects are found in other archaeological sites.

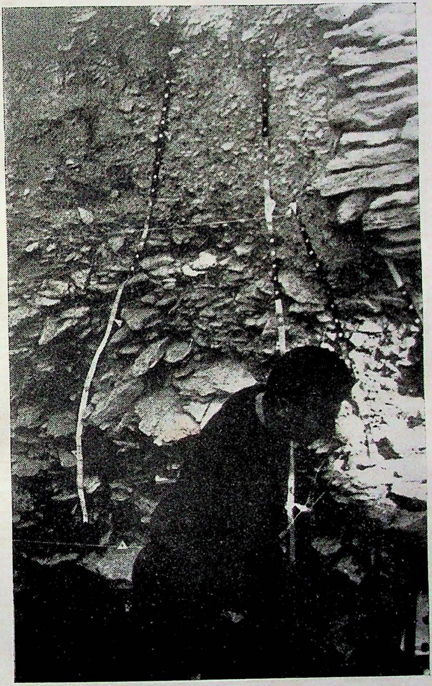
DURATION AND PERSONNEL FOR EXCAVATION :

In France, the excavations of such prehistoric sites are conducted by university departments, museums, or by the Government research department through their regional officers. They are usually undertaken during the summer months July to September. The pace of work is slow and at most of the sites the excavation is spread over many years. In fact instances may be quoted in which two generations have been excavating in the same region, e.g., the family of H. MARTIN at La Quina, where the daughter of late Dr. H. MARTIN has continued the excavation work of her father. The number of persons actually engaged at any one site is extremely limited. At times only the chief excavator himself or herself does the entire work or sometimes he gets the help from his family members or friends. Hired labour is very rarely employed on account of high labour charges, and, as stated above, since the work is of a delicate nature and requires patience and hence time consuming, the expenditure on labourers is considered undesirable. If the excavation party is from an University then the professor who undertakes such work has the advantage of getting help from his student-trainees and since the work is conducted in the vacation and as it forms part of their curriculum, the students also carry out this job seriously.

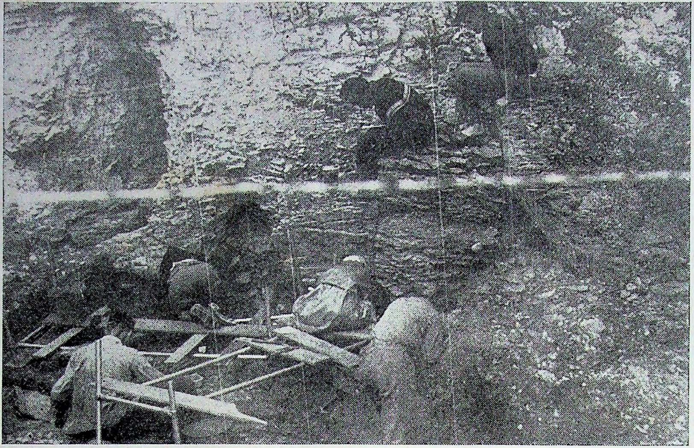
The students are required to make their own arrangements of tents and other camp equipment and have also to bear the cost of food and travelling. The organizers of such training camps supply only the excavation tools and occasionally share a part of the cost on the camp establishment. Thus it may be a group of single family members, or friends, or a camp organized on behalf of the educational institute, the entire expenditure on the excavation that the Institute has to bear works out much less in comparison with Indian Universities.

At the excavation camp there is always one surveyor or draughtsman who looks after the entire survey work and drawing of important sections exposed in the excavation. But day to day details at each stage of the excavation in progress are recorded and drawn on sectioned papers by the person who actually performs the digging operations. The drawings and notes are constantly checked by the chief excavator when these are being recorded, with the result that the final drafting of the report becomes easy.

All those who participate in the camp may not be necessarily qualified in some branch of archaeology. On the other hand, whosoever is interested in this type of work is welcome and then he may be a student of arts or languages or a science student of physics, chemistry, biology or mathematics or a law graduate or even an employee in some office performing duties of a clerk, or a store-keeper.



Excavations in Prehistoric
caves in France



Method of plotting objects

Examples may be quoted of employed persons who take their annual leave and join the camps which, being located usually away from the big cities, provide a calm life and holiday fun. Actually persons of varied occupations form a better group, for they are always enthusiastic and keen on understanding something new and exciting. In another way a group of varied scholarship is in fact beneficial also. A student of physics trained in prospecting by electrical methods is always helpful in tracing the buried archaeological structures like Roman relics and at the cave-sites by conducting experiments on the exposed sections in the excavation in locating the hard and compact layers and vacant pockets or holes or channels. A palaeobotanist besides contributing labour in excavation collects pollen data and thereby helps the chief excavator to reconstruct the environmental details of the past climate and flora of the region. The physical anthropologist and zoology students are useful for analysing on the spot the human and animal bones encountered in the excavation.

CAMP ESTABLISHMENT AND MANAGEMENT :

As far as possible the camp is established in close vicinity of the excavation site so as to avoid transport difficulties as usually the party does not have any official vehicle. But if need arises it is met by the persons who have got their own cars. In fact some persons always come with their private cars which are conveniently utilized in contingencies at the camp and also for the exploration work. Working hours are the same as in our country, i.e., about eight hours a day.

Minimum discipline is observed by the campers but since the majority of the members are voluntary workers, no need is felt for strict supervision. Even then the behaviour of all the camp inmates usually remains remarkably exemplary. A common mess for all including the supervisory staff is arranged by the members. The work of cooking and serving is volunteered usually by the lady members with the help of one or two male members. Every kind of work from cooking to cleaning is done by the members themselves without employing any labourer.

EXPLORATION:

As is always the practice, the exploration of the region surrounding the excavation site is also carried out simultaneously and new caves located or old ones re-examined for their structural studies and archaeological contents. Many clubs and societies, either themselves organize or encourage explorations in mountainous regions. A member of a speliological club can also get insured against the dangers and risks for a limited period during the exploration work. Unlike the caves in tropical lands, as in India, the caves in France are generally free from reptiles and dangerous insects. But usually they have a very intricate pattern of inner passages and blind channels, underground ponds and in places the collapsing roofs pose a danger. The caves are dark, moist and cold and sometimes the passages are narrow and flanked by angular projections with the result that even crawling becomes extremely difficult.

The tools used for excavation consist of a short spade or trawl, buckets for transporting loose deposit for washing and separating minute antiquity that could not be picked up directly from the soil, a trowel, a small pick-axe, brush, poker-

like needle. Crow-bars or large pick-axes are used only when large stones or sterile debris is to be removed. The student trainees are, however, never allowed to use bigger tools. If water from a stream or a well is available in the vicinity, the loose deposit is carried there either in buckets or on hand-driven trollies and if the material is in large quantities even by improvised rope-ways. Generally for sorting cave deposit dry sieves are not used. Instead, the soil is kept in a sieve and then inserted in the water so that fine clay particles are automatically washed off and the coarse material along with tiny objects like bones and stone fragments remain on the sieve.

For the location measurements of the '*in situ*' objects exposed in the excavation a scaled-net is very conveniently employed. This is a simple device of aluminium-pipe frame in the form of a square with each side measuring one meter. Each of the sides is further divided at an interval of 10 cms., and by passing threads through the holes at this interval a net is obtained. The square frame can be adjusted to an appropriate level by clamping on four vertical aluminium pipes at the corners. While taking readings, one corner of this frame is made to coincide with one of the index points. These index points are the intersections of the two co-ordinates of the sector plan of the entire excavation area, and they are shown by dropping threads from the net above. The measured distances of the object along the two co-ordinates can then be easily transferred on the sectioned paper with an appropriate decimal scale.

For the *in situ* recording of human skeletons a chart showing all the bones and joints of the skeleton in the outline of a human-body is employed. Orientation is given on this chart by taking compass-bearing and the displaced or missing parts of the skeleton can be shown by shading those parts on the chart. Besides, all the bones are listed on the same chart. This facilitates complete recording of the skeletons before their eventual lifting from the excavation trench for further treatment. Of course, complete drawings by competent persons are also done in such cases.

All the antiquities are washed with water, and allowed to dry. The broken stone objects and bone material are treated with couchoue (rubber) solution, numbered and recorded in the register. No separate staff is assigned for these duties but these are required to be done by the person or persons who have dug that material.

EXCAVATION SITES VISITED :

During his stay in France in 1962 the writer got an opportunity of participating in the excavation work for a few days. This included the excavation at Escolive near Vermonten at the Roman site and at Arey-Sur-Cure. Both these excavations were conducted by Prof. LEROI GOURHAN for training the students from the University of Sorborne at Paris,. The first site was a cemetery site interesting for the number of skeletons.

Some details of the excavation work at Arey-Sur-Cure are given below for, the author had spent a longer time at this excavation. Opportunity was also taken to visit some other sites where excavation work was in progress. These

included La Quina site where MLLE H. MARTIN the daughter of Dr. H. MARTIN well known for his Fonte Chevade excavation is conducting excavations and La Placard cave near Vilhonneur village under excavation by ABBE ROCHE. Besides, several other excavated cave sites were seen.

The region around Arey-Sur-Cure, a small village on the river Cure, a tributary of the Yonne, is known since long for the natural caves and rock-shelters in limestones. Some of these contain prehistoric deposits and specimens of prehistoric cave art, some possess interesting stalactite and stalagmite formations, while some are simple caverns with intricate passages inside. Prof. LEROI GOURHYN has been excavating at one or two of these caves that are situated on the river about 5 kms from the village. Of these one is described as ' Grotte de Renne ' after the finds of reindeer bones in the deposit and the adjacent one is called ' Grotte de Bison' for the discovery of bones of bison in it. While digging in ' Grotte de Renne ' another small opening was struck in the hill which by a very narrow passage leads to what is described as ' Gallerie Mousterian '. The inner path is so narrow that one is required to crawl flat for about 50 meters to reach the interior wherein lie *in situ* piles of animal bones and several Mousterian implements which have remained undisturbed for thousands of years. Another narrow cave called Grotte de Cheval has the entrance at the foot of the hill a little to the right of the Grotte de Renne. After traversing about 100 meters of intricate passage with pits and depressions one comes across on the rocks several engravings of horse, bison, and mammoth.

The excavation in Grotte de Renne has revealed the stratigraphy as detailed in fig.[1] (Sketch model of both the caves and section of Grotte de Renne) The work in Grotte de Bison was taken up at the latest camp (1962). A block diagram showing the positions of both these caves is also given. The results o excavations in Grotte de Renne clearly show the richness of this prehistoric cave which was in occupation throughout the Upper Palaeolithic period and the late phases of the Middle Palaeolithic.

Caves of prehistoric importance are so far not known in India. This may be partly due to the lack of exploration in this direction. But surveys in the Kurnool limestone area which contains several caverns and in the Vindhyan region which has numerous rock-shelters have brought out nothing of prehistoric interest within such caves or shelters.

As a rule all the prehistoric sites in India seem to be open-air stations. Perhaps Indian climate during Pleistocene did not experience marked temperature variations that could have compelled the inhabitants of open-air camps to move to the sheltered places.

THE SAPTANAGAS FROM DEVGERI

by

NAGARAJA RAO M. S. &
JAMKHEDKAR A. P.

The village Devgeri (tq. Haveri. Dist. Dharwar), Devaṁgeri of the epigraphs, contains a number of structural temples, inscriptions and sculptures datable to the period between 9th and 14th centuries A. D. Of these, the temple of Mallikārjuna is noteworthy on account of the sculptures and the inscriptions. In front of the temple is kept a large panel (now measuring 7′ × 19′) carved with seven nāga figures (the seventh being mutilated) having human heads and coiled bodies, in bold relief (pl. I) . The figures are all shown wearing an exquisite Karaṇḍamukuṭa and large karṇakuṇḍalas. The raised eyebrows, snubbed nose, bulging out eyes, protruding canine teeth and the grin on the face give them a ferocious expression. Another interesting feature is that they have 1, 2, 3 or more nāga hoods at the base of the front of the mukuṭas, thus indicating their position in the row, resulting in the last one having 7 nāga hoods.

The panel described above is unique in the sense that it is difficult to find a parallel to it elsewhere, and also not much is known about the iconographical features of such figures. However, the panel can be identified as that of the seven great Nāgas (Sapta nāgas) who according to the *Mayaśilpa* are Vāsuki, Takṣaka, Karkoṭaka, Padma, Mahāpadma, Śaṅkhapāla and Kulika.[1]

As already noted, the Nāgas have been shown with human heads and serpentine bodies. This is very well in keeping with the iconographical characteristics detailed in the *Śilparatna*[2]. The text also prescribes that such figures should be covered with hoods having 1,3,5,7 or 9 heads.[3] In this respect the sculptor appears to have slightly departed from the inconographical canons, inasmuch as instead of covering the heads with hoods, he has adorned them symbolically with miniature nagahoods with one or more, at the base of the karaṇḍamukuṭa according to their position in the panel and has also presented 2,4, and 6 hoods on the respective nāgas as against the prescription of the *Śilparatna*, already referred to.

1. Gopinatha Rao, T. A., *Elements of Hindu Iconography*, Vol. 2, Pt. 2., pp. 556–557; App. p. 274.
2. *Ibid.*, p. 556; App. p. 274.

   नागानां वक्ष्यते रूपं नाभेरूर्ध्वं नराकृतिः ।
   सर्पाकारमधोभागं मस्तके भोगमण्डलम् ।।
   एकं फणात्रयं वाऽपि पञ्च वा सप्त वा नव ।
   द्विजिह्वास्ते विधातव्या खड्गचर्मकरैर्युताः ।।

   शिल्परत्नम् अ. ५
3. *Ibid.*

It is interesting to note that the ornamentation of the figures is in keeping with the rules mentioned in the *Amśumadbhedāgama* which states that nāgas should be adorned with a karaṇḍamukuṭa.[4] It further states that the figures should have 3 eyes and 4 arms. The panel in question, however, does not portray the figures with arms for the simple reason that they are shown with reptile body and human head, the latter having only two eyes.

It is very difficult to state as to what date the panel belongs, since no parallel is forthcoming. An attempt, however, may be made to date it on stylistic grounds. The karaṇḍamukuṭa worn by the Nāgas consists of schematic concentric bands indicative of the matted hair similar to that worn by Maheśvara, in the Umāmaheśa panel at Haveri.[5] The latter is dated to the later Chalukyan period, since the temple of Siddheśvara in which it is placed is dated to that epoch.[6] Again the well carved, raised eye-brows in bold relief and the disc-or ring-shaped ear ornaments have very close parallels in the sculptured panels at Belur.[7] On stylistic grounds, therefore, the panel can be ascribed to A. D. 12th 13th cents. when the Later Chalukyas held sway over this region.

The epigraphic evidence from Devgeri and the neighbourhood also helps us in dating the panel. The epigraphs in question belong to the reigns of Someśvara I, II, III and Vikramāditya VI of the later Chalukyan family and Singhaṇa of Yādava dynasty. According to them, Devaṁgeri with the neighboruing villages of Kolur and Kulenur formed the " Manneya " or seigniory of the division known as Bāsavūr 140. This was under the control of the Mahāmaṇḍaleśvaras, who claimed to be the successors of Jīmūtavāhana and of the ' Khecara vaṁśa ' (race of birds or vidyādharas) and had a snake on their banner (sarpadhvajas)[8]. They also had connections with the Śilāhāras of southern Konkan. They were, however, the feudatories of the Chālukyan and the Yādava monarchs. Since they are said to be snake-bannered, they held snakes or the nāgas in high esteem and could well have worshipped them.

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4. *Ibid.*, p. 556. App. p. 273.
5. Cf. GOPINATHA RAO, T. A., *Op. cit.* Pl. XXVI fig. 1 facing page 137
6. COUSENS H. *Chalukyan Architecture, pp.* 85–87.
7. SIVARAMA MURTI, C., *Indian Sculpture,* Pl. 46.
8. EI, Vol. XIX, pp. 179–197, Inscriptions A, B, C, D, E and F.

VIṢṆU IN VIŚVARŪPA FROM NEPAL

by
SHARMA P. R.

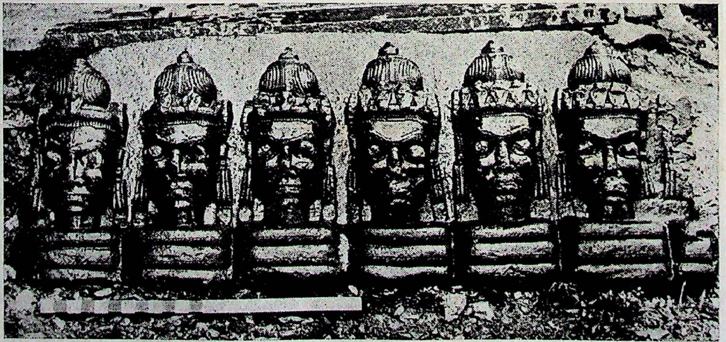
An image of Viṣṇu representing him in his *Viśvarūpa* form is lying in the courtyard of the Cāṅgu temple, 2 miles north of Bhaktapur in the Vagmati valley. This is a unique and unparalleled image for the grandeur of its theme. It depicts most successfully the concept of all-embracingness and all-purvasiveness of the Almighty and His boundless form. Never has the artist so successfully and fluently described the immeasureable aspect of Viśvarūpa, the destroyer as well as the sustainer of the Universe with the medium of his chisel. One who looks at this creation cannot but remain dazed by the beauty and magnificence of the image.

The image, 28" high, is carved on a block of hard granite. It is unfortunately mutilated on the right towards the top. Otherwise it is in an excellent state of preservation.

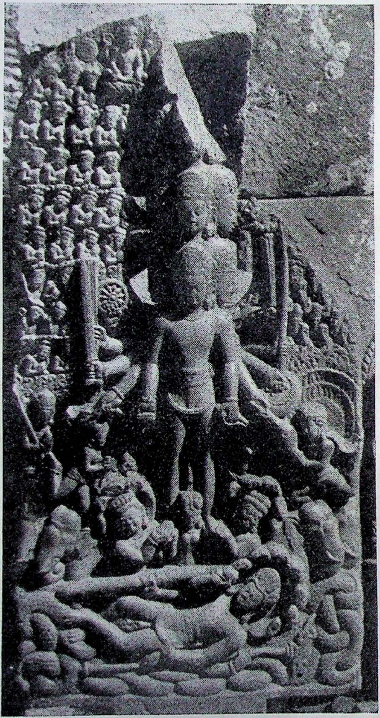
Before describing the image proper, it would not be quite out of place here to give a brief glimpse of the artistic background of the period to which the sculpture under study is ascribed. It rather becomes incumbent when we know the fact that no real attempt has yet been made to assess the sculptural wealth of Nepal except bare reproduction of a few sculptures here and there.

The Licchavi period in the history of Nepal from the time of King Mānadeva I (A. D. 460-505) ushers in a new era of achievement in Nepal in varied fields of which one is the sculptural art. A high tide of artistic verve, having its origin in the plains of India swept the whole country to a great artistic activity in this period. It was an efflorescence, the kind of which the country saw neither before nor afterwards. It lasted for about three centuries in an unabated spirit since its inception in the 5th cent. A. D. This great artistic upsurge was mostly tapped by the Vaiṣṇavites to carve a number of beautiful Viṣṇu images which form the best specimens of the period. A fine array of these images can be seen in the courtyard of the Cāṅgu temple where we can have the Garuḍa-Nārāyāṇa representing Viṣṇu mounted on his vāhana Garuḍa and the Trivikrama and Nṛsiṁha forms. This great assemblage of excellent pieces sometimes tempts one to refer to the classical art of Nepal as the Cāṅgu school of art.

The beginning of image carving in Nepal antedates the Christian era as judged by an image of Yakṣa lying near the temple of Paśupati. There are a few other instances dateable to the 2nd cent. A. D. influenced by the Mathura School of the Kushana period. But the real beginnings of sculptural art did not take place till the 5th cent. A. D. Not only the images are more in number from this period onwards but also unparalleled for displaying a powerful execution and their high appealing quality.



The Sapta Nagas, (Devgeri, Dist. Dharwar).



Visnu in Visvarupa Form (Nepal)

Another interesting fact arises from the study of the Nepalese images. It appears that the art of image carving from the beginning to the 12th-13th centuries A. D., was the result of a deliberate and conscious import of the artistic styles from North India. There is little of native evolution in the images of Nepal of the 5th cent. which is traceable to its few early images. In fact in all the periods Nepal drew so profusely from the contemporary schools of India that there hardly arose any opportunity to the native style to progress. Hence the earliest images have the impact of the Mathura school; the Classical images, of the Gupta-Vākāṭaka; later still, of the Pāla school of Bengal. Nevertheless it is in no way true that the Nepalese images have no individuality of their own. In fact they had many in which the perfect balance, charming gracefulness, the costumes consisting of ekāvalis, udarabandha, dhoti, kuṇḍalas, mukuṭas etc., are the most prominent. Yet the fact must be conceded that the Nepalese images mainly depended on the contemporary schools of Northern India for style and execution. India was the main sustaining force for this art of Nepal. Never is the point so glaringly illustrated as in the fact that no sooner the sculptural art declined in India than it declined in Nepal too.

Viṣṇu, in his mainfestation of Viśvarūpa[1] (Pl. I), stands in the centre in ' samabhaṅga ' pose over the palms of a pair of Nāga and a Nāgakanyā. He has twelve heads arranged in four tiers of three each and has ten hands. The upward extension of the heads carries an impression of his transcendental nature capable of pervading the entire Universe. The conception of his immeasureable dimension is conveyed through the representation of three different regions which he pervades. Each region is meticulously arranged. The nether region, the Pātāla is represented by the Nāgas, on whose palms he is standing. The middle region, the earth, is suggested by four couchant elephants. Mythology tells us that the earth is supported by elephants. The etherial region, the heaven or the sky, is conveyed by the flying vidyādharas and kinnaris. Along the two sides of the slab are represented innumerable figures, all shown with folded hands paying homage to the Lord, dazed and overwhelmed by his sudden mainfestation. The bearded figures on the right could be ṛsis. On the left top is a small figure with four arms and can be identified as Śiva by the attributes he is holding. To his right is a plain disc which may well be the Sun. On the corresponding side which is mutilated could have been Brahma and the moon. Below, to the right of the Lord, is a person who bows slightly with folded arms. He has a bow hung to his right shoulder and could be identified as Arjuna, to whom the Viśvarūpa form of the Lord was revealed in the battlefield.

The sculpture under study presents a remarkable semblance to the idea of Viśvarūpa as expounded in the XI canto of the Gītā.

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[1] The present Visvarupa does not resemble the four-faced Visvarupa described by Gopinatha Rao. (See Rao, T.A.G., *Elements of Hindu Iconography*, Vol. I., Pt. 1, p. 258). The four faced Visvarupa carries the head of a boar in his right profile and that of Nrsimha in his left. In the rear, sometimes on top also, is found the head of Kapila. A beautiful example of this kind is found at Kanauj. (See Sivaramamurti.c., *Indian Sculpture*, Pl. 33.)

Dyāvāpṛthivyoridamantaram hi
āyāptam tvayaikena diśaśca sarvaḥ ।
Dṛṣṭvādbhutam rūpamugram tavedam ।
Lokatrayam pravyathitam mahātman[2] ॥

" Oh Mahātman ! thou alone hast embraced the entire directions, the heaven, the earth and the intervening space. Beholding thy awful and marvellous form, the triple world is shaken. "

The diety is adorned with kirīta, hāra, kuṇḍalas, udarabandha, dhoti and yajñopavīta. In his hands, he holds from the right top - cakra, bāṇa, khaḍga a double-headed hatchet and the vījapūraka In the corresponding left hands are gadā, dhanus, shield, musala and śaṅkha.

At the bottom of the slab, yet another scene is depicted. Here Viśṇu is shown resting on the coils of the eternal serpent Ādiśeṣa. The seven hoods of the Nāga form a canopy over the head of the Lord . The attributes held by the deity are of a peculiar nature and are not to be seen in any other Śeṣaśāyi sculputres of Nepal. The upper right hand probably has a lotus flower, the upper left a makara-dhvaja (?), lower right a musala and the lower left akimbo. The gadā is seen lying in the fore-ground. It was in his Anantaśāyin form that the Lord is said to have created the world by the mortal remains of the two demons Madhu and Kaiṭabha.

A most interesting anology to the image in question could be drawn from the so-called Trimūrti of Elephanta The threefold arrangement of the εds in each tier in our image so vividly recalls the fashion in which they are arranged in the Elephanta sculpture. Another comparison could be made with the ' Śiva Trinity and Host ' from Parel[3]. But the latter is an earlier sculpture dated to c. 600 A.D.

It would be rather difficult to date the sculpture under study precisely. But judging from the general style, the image represents the characterstics of the peak of the Classical period of Nepal, discussed above. The paraphernalia consisting of ekāvali, three-crested mukuṭa, an udarabandha, a dhoti and a tassel hanging as a loop over the thighs of the image also conform to that of the sculptures belonging to the period between 5th cent. and 8th cent. A.D. The resemblances in the arrangement of the heads with the Trimūrti of Elephanta may prompt one to date the image slightly later than that of Trimūrti, that is, to late 8th cent. A.D.

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2 BHAGAVADGITA, Cant. XI, verse 20.
A twenty armed sculpture carved in relief is kept in Rajasahi Museum. It is the only image which partly attempts to represent the Visvarupa form in the spirit of Gita. It is, however, a relief of the 11th cent. A.D. and thus later than our sculpture. (see BANERJEA, J. N., *Development of Hindu Iconography*, p. 426, Pl. XXVI, 2; and also BANERJEA, J. N., *JISOA*, Vol. XIII, pp. 84-89.)

3 ZIMMER, H., T *The Art of Indian Asia*, Vol. I, (Text), P1. B 16 facing page 247.

DOWNFALL OF THE MARATHAS

by
MATE M. S.

Ever since serious study of Maratha history started, the causes of the downfall of the Marathas or of the Peshwas, has become a topic and problem upon which a good deal of attention has been bestowed. The fall of the Marathas, like the downfall of any other political power of the past is undoubtedly a topic fit for academic discussion. The problem however, did not remain academic for a long time. The collapse of the Maratha power was an event too recent to allow thae sort of mental detachment required for the proper evaluation of facts and events. Instead of being treated as yet another example of the ' rise and fall ' of political powers that form an important aspect of human history, it was turned into a session for apportioning the blame. The establishment of British power in India was looked upon—at least in Maharashtra—as a direct consequence of the failure of the Marathas. The Maratha fortunes were at this time being presided over by the Peshwas. The question no longer remained—How did the downfall come about, it was phrased ' Who lost the independence ? ' With this paraphrasing, the question at once became much more realistic and poignant. Considerations of contemporary politics and policies, of caste and communal prejudices came into play. This added a most unwelcome overtone to the entire discussion. Modifications in earlier arguments and theories were bound to occur as more and more data became available. But it would be difficult to say that all research on Maratha history during the last twenty-five years or more is purely academic. Leaving aside the prejudiced pamphleteering of the early thirties of this century, even the so-called scholarly works do not observe enough restraint or balance. Here, being scholars by profession, the authors have taken care to clothe their arguments with logical plausibility. Arguments supported by data are presented, but not all the facts nor all the data. Even the latest publications on Maratha history are not entirely free of this bias. The Life of Sambhaji written by BENDRE[1] is a classic of this type where fact and fiction are blended so finely as to obtain a distorted picture. It could be said therefore, that the treatment of Maratha history and the researches therein have been less fruitful academically than the volume of such literature would lead one to believe. And hence no historian has till now thought of applying a very well known and recognised factor in the analysis of the causes of the downfall of the Maratha power. In the following paragraphs the arguments till now advanced are summarised first.

It is generally conceded that the high idealism that informed Shivaji and his administration was lacking in the Peshwa period. Shivaji and his colleagues and his subordinates devoted themselves to the destruction of Islamic power

1 BENDRE V. S., *Chhatrapati Sambhaji Maharaj* (Marathi) Author, Poona, 1960

from Maharashtra and the foundation of a kingdom of the Hindus, known as Hindavi Swarajya. This is well attested to by Shivaji's actions both in the spheres of politics and administration. In the pursuit of this high ideal neither Shivaji nor his colleagues paid any attention to personal saftey or gain or glory. It was a selfless job. The Peshwa regime is the very antithesis of this idealism. Whereas Shivaji asserted the independent nature of his kingdom through ritual coronation, Balaji Vishvanath and his successors based their claims on some Imperial Sanads extracted from a helpless Emperor. In theory they were the subordinates of the Mughul Emperors and in practice they often subordinated their interests to those of Delhi. Once the idealism of the old days was lost sight of, several harmful results followed. The direction of policy became more opportunistic. Second but much more detrimental was the loss of cohesion. Once the tie of common ideal that bound the various people was loosened, unity was difficult to achieve and maintain. People stood together only so long as their interests were served. This was amply illustrated during the later years of the Peshwa rule.

As already stated, once idealism fell from the pedestal, self-interest pure and simple took its place. All persons, big and small — including the Peshwas–were more concerned with material personal gains than state-interests. Self-aggrandizement took the place of self-denial of Shivaji's days. This internal competition, which as some historians have aptly pointed out had its origins in the times of Rajaram or even in the reign prior to his, had the upper hand. Some examples could be quoted. The destruction of the Dabhades in Gujarat was an act of folly. The constant harassment and checkmating of Raghoji Bhonsale of Nagpur in Bengal was still more foolish;[2] nothing but the idea of monetary gain explains the Peshwa's action. The destruction of the navy of the Angres was a crime. It denuded the Marathas of the one weapon that would have counted in any struggle with the British. This long catalogue does not end here, it continues till the very end. There were squabbles and dissensions not only between the various Maratha chiefs on the one hand and the Peshwas on the other, even the chiefs fought among themselves. The differences between the Holkars and the Shindes contributed in no mean degree to the catastrophe of Panipat. Within the Peshwa family itself, no unity of purpose was to be found. The dealings of the Peshwas and other chiefs immediately after and before the assassination of Narayan Rao betray a total lack of any sense of national unity. To sum up, disunity was the bitter fruit that the tree of self-interest bore during the Peshwa period. Disunity brought defeat.

Some scholars have maintained that the lowering of the prestige and influence of the house of the Chhatrapatis that was consequent on the ascendency of the Peshwas was detrimental to national interests. They contend that the Chhatrapati was a visible symbol of national unity, of the glorious traditions of the past and the sole link with the name of Shivaji, and by allowing it to lapse into obscurity the Peshwas lost a good rallying point. Efforts have been made to show that the later Peshwas, especially the third one, Balaji Bajirao strove to keep

2 SHEJWALKAR T. S., *BDCRI*, Vol. 1 pp. 120-122

the Chhatrapati a nonentity, in order to avoid any competition for the leadership of the nation.

The expansion of British power in India was of course recognised as the most significant single factor in this process by all the students of Maratha history. The British won through superior weapons and tactics !

A host of other factors have been cited. They are, what might be called contributory causes. The Peshwas defeated the Nizam often, but did not destroy him, thus keeping alive a dangerous foe too near their home for their own comfort and safety. It is also maintained that under the Peshwas only certain communities got any lift and some monopolised the higher positions, leading to bitterness and rancour. Then, the several Peshwas had various shortcomings, the most important one being the lack of political foresight.

All these arguments could be shown to be only partially true, but that does not happen to be the subject of the present discussion. What is to be shown here is that those scholars who are supposed to have shown a keen insight into Maratha history, and have arrived at the results cited above, have failed to grasp the true implications of the words ' British power '.

The rise of British power in India has been always noted as one of the important factors that led to the downfall of the Maratha empire. However, the wider implications of the term ' British power ' have never been properly understood. Discussing the ' international factors in Indian politics', SARDESAI, perhaps the most level-headed and sober historian of this period has only the American War of Independence to point out. He says, ' The news of these disasters reached India in the early months of 1778 and fired Hastings'[3] ambition for retrieving the lost fortunes of England by creating a new empire in India '. Next he has pointed out how the rivalries between the French and the British were utilised by some statesmen of this time. However, the appreciation of external or foreign threat that confronted the Maratha nation in the form of the East India Company as the representative of England has not reached deeper. Its full significance has certainly not been realised by any of the historians. They have never given thought to the question of the nature of the opposition the Peshwas faced and failed to tackle.

The struggle between the Peshwas and the British was not merely a struggle between two political rivals. It could never be compared with the clashes between the Mughuls and the Marathas or the latter and the Nizam. The objective in all these contests was the same, namely political supremacy, but the fundamental character of the contestants was different in each case. The Mughuls, Marathas and the Nizam could be treated on the same plane. All of them were medieval powers. Their economic systems were alike, based entirely on agriculture and the economy was definitely pre-industrial. Their social and political organisations were attuned to this economic framework. Their ways of thinking were moulded by the logic of this economic, social and political framework. So long as the Peshwas were dealing with powers that fitted into this pattern, they were generally

3 SARDESAI G. S., *New History of the Marathas*, Vol. 3, pp. 67-69

successful. By about the middle of the 18th century the Mughuls as a political power did not count for much. The battle of Panipat was no doubt a great set-back. But under Madhav Rao I the Marathas had regained their lost prestige and their persistent rival the Nizam was severely punished at Rakshasbhuban. The northern planes, from Punjab to Bengal were in no position to offer any decisive resistance, political or military, to the Maratha onslaught. Even under the rule of the Barabhai junta, things were neither dismal nor gloomy. The remedy, open to all medieval powers was open for the Maratha nation as well. When it was realised that the Peshwa family was in no position to provide effective leadership, and the successive Peshwas had proved incapable, they could have been displaced and their place could have been taken by more able men. The family of the Chhatrapatis had not thrown forth any remarkable man after Shahu, but opportunity was open to all. None came forth. *All these considerations, of course, could be valid only if India had remained medieval.* But it did not or rather could not isolate itself from the currents of world politics. Did the Peshwas or their assistants understand the real potential of the White Trader ? Had they any idea of what was the source of their strength ? In other words had they understood the Industrial Revolution and its immense implications ? The answer to all these queries would be a firm *no*. And for that the Peshwas could be blamed. But the gravity of this crime could be obviated by certain circumstances. Had any other power or prince in India shown such grasp ? The Nizam, who was famous for his cunning and shrewd brain never as much as touched the fringes of the problem. Nor did any other Indian statesman. Mahadaji Shinde was as blissfully ignorant of the danger as Raghoji Bhosale. The Nawabs of Arcot and the Subhedars of Bengal betrayed the same lack of comprehension.

All this would not seem so very surprising if one just considers the world situation of those days. It would be found that the same phenomenon as in India was in evidence throughout the world. There was no country in this wide world that was not subjected to either direct or indirect political or economic hegemony of Europe. Mercantilism first, Colonialism next and Imperialism the last, between themselves had imparted such a momentum to Western expansion that it had become irresistable. No country outside Europe has resisted this pressure in any successful manner. Imperialism penetrated deep into the dark forests of Africa as speedily and surely as it reached the icy wilderness of Canada. Some countries managed to preserve a semblance of independence, not because of any special virtue of theirs, it was practically in spite of themselves. They happened to be coveted by more than one nation and the latter found it more convenient to share the spoils rather than kill the egg-laying goose. That is how Persia could maintain its independence, at least nominally. That is how Afghanistan and Nepal remained free. Subtler forms of imperialism came to be developed and fact and fiction were blended rather finely. The fact of foreign control over Iranian oil and the fiction of Persian independence, the fact of Chinese economic subjugation and of the political sovereignty of China, all belong to this category. It thus becomes evident that the phenomenon of Modernism springing from the Industrial Revolution was never comprehended by the Medieval world. And not knowing who

was the enemy and what was the source of his strength, medieval world had to give way before the modern.

Now the entire phenomenon of the conquest of India by the British formed part of this general world trend. The Britishers themselves meant nothing much, they were the advance guards of a new civilisation based on science and the old world in India, as everywhere in the world had to accept defeat and vanish before the might of the new one. Nor was it relevant whether the Peshwas ruled or the the Bhosales ruled. For the Anglo-Maratha struggle was not a struggle between two dynasties or two nations, it was a conflict between two civilisations, between two ways of life, between the old order and the new. And true to nature not one nation survived this revolutionary sweep. Only one nation, and one alone provided a sharp contrast to the general rule, and that was Japan. How it could maintain its independence and how that was sustained by a thorough reorientation of Japanese society are facts too well-known to be repeated here. The point is that it survived by becoming Western mentally though it never went under the physical domination of the West.

Thus a person who has to evaluate the role of the Marathas in general and the Peshwas in particular and understand the causes of the downfall of Maratha power, has to keep in mind the great fact of the powerful revolutionary tide that was just about to engulf the entire world. They were essentially a medieval power and were fairly successful so long as they were dealing with other medieval powers That they failed to understand the nature of the forces converging on them is true But the forces were so novel as to confound anybody and the Peshwas share the failure with the rest of the nations of the world.

FAMILY POSITION AND HIGHER EDUCATION*

by
REDDY P. H.

Since many years, a number of researchers have been trying to find out the causes for differential achievement in education by different individuals. But there is no close agreement as to what are the factors that account for high academic or educational achievement. In fact, there are numerous factors such as birth order, intelligence, motivation of the individual and the relationship between the socializing agencies and the socializee. Although all play some role, the role played by the socializing agencies is unique. Again among the socializing agencies, family comes to the forefront and the socio-economic position of the family may be regarded as the focal determinant of an individual's achievement score.

It has often been said that the structure of the family plays an important role in the diffusion of cultural standards and the formation of estimable goal to the younger generation. This is particularly true of the Hindu social structure where the fate of the child is determined by the father or the breadwinner. Writing about father-son relationship in Hindu society KOESTLER observes : "All decisions were made for him by his elders, they chose his bride for him while he was a child or before he was even born; his education, vocational choice and later career would be decided for him, after more or less liberal discussions, yet ultimately nevertheless by others."[1] There is something wrong with the socialization process in a Hindu family. Hindu children are brought up by their parents at the cost of their own pains and discomforts. The child is never allowed to think or act independetly as long as the parents are alive. As CARSTAIRS says, "... that Hindu children, almost without exception, begin life with an abundantly rewarding experience. During the first year, they are never separated from their mothers for more than a short time, and they are given the breast generously, whenever they feel hungry and upset. An infant's mother is his willing slave, and he becomes something of a tyrant."[2] Even in the West, where the individual interests precede the famililial interests, the child cannot escape from the parental influence. Both father and mother, more or less equally influence the child's cultural evaluation and ambitions. But in Hindu social structure, it is the father or the male tutelar

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*I express my grateful thanks to Dr. Y. B. DAMLE, my Research Professor, who has gone through the earlier draft of this paper. I also thank Lt. Col. K. N. SHARMA, the Dean of the Armed Forces Medical College for help in thy field work,

1 KOESTLER, A., *The Lotus and the Robot*, Hutchinson, 1961, p. 154.

2 CARSTAIRS, G. M., *The Twice-Born: a study of a community of high-caste Hindus*, The Hogarth Press London, 1957, p. 157.

who influences the child most and the mother has little or no influence as far as, at least, the educational ambitions of the child are concerned. It is due to the fact that in Hindu family leadership is centralized in the father or the guardian and the position of the woman is almost insignificant. Thus the father or the guardian, mostly a male, becomes a sort of compulsory reference individual for the child. To quote CARSTAIRS again, " He (father) is all powerful, and must be approached in an attitude of complete submission; and it is in relations to him that one learns the imperative social duty of suppressing one's appetites, and desires, and every demonstration of emotion. "[3]

MERTON is of the opinion that ' ... many parents confronted with personal " failure " or limited " success " may mute their original goal-emphasis and may defer further efforts to reach the goal, attempting to reach it vicariously through their children. '[4] It is not only the parents confronted with personal " failure " or limited " success " but also the parents confronted with complete " success " who want their children to accomplish high academic or educational goals. It is all the more easy for the parents confronted with complete "success" to make their children achieve high academic goals. The present paper may, therefore, be viewed as an attempt to show that the educational achievement of an individual depends mostly upon the position of the family—social, educational and economic. In order to test this hypothesis, I studied 165 students in the under-graduate wing of the Armed Forces Medical College in Poona where admissions are made on the basis of merit from all over India. So it will be very interesting to study the social background of these meritorious students.

METHOD AND PROCEDURE

Data were obtained from two sources. First, a printed questionnaire, was administered among the students, which contains questions regarding the education and occupation of their parents, the total annual income of their families, the number of brothers and sisters elder and younger to them etc. Second, data were also obtained through informal interviews and conversations with some of the students.

AGE GROUPS

The date of birth given by the students in the questionnaire was regarded as authentic and this age was perhaps their recorded age. It is sometimes the practice to reduce the age of the students at the Primary or High School level, either by the parents or by the students themselves, to gain certain advantages in future. For example, one might get admission into a technical or professional college, or one might appear for the State or Union Public Service Commission examinations if one's recorded age is within the prescribed age limit. Hence the following table is subject to such consideration.

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3 *Ibid.*, p. 76.

4 MERTON, R. K., *Social Theory and Social Structure*, (Enlarged Edn.), The Free Press, Glencoe, III., 1957, p. 158.

TABLE I

AGE DISTRIBUTION

Age Groups	No. of Students	%
17-18	29	17·6
18-19	52	31·5
19-20	35	21·2
20-21	28	17·0
21-22	10	6·1
22 and over	6	3·6
Not given	5	3·0
Total	165	100

The average age of the students was 19 years and 2 months. Most of the students, whose age was over 20 years, were already graduates and some of them were even post-graduates. That is, their educational qualification was higher than that of the minimum required for admission into the college. Taking this into consideration, the mean age of the students was not more than their counterparts in other countries.

SURVIVAL ORDER AND SIZE OF FAMILIES

An attempt was made to find the survival order of the students and the size of their families. I think it is better to call survival order instead of birth order because, when we ask the students to give the number of brothers and sisters younger and elder to them, they take only the survivors into consideration.

TABLE II

SURVIVAL ORDER AND FAMILY SIZE

Suvrvival Order	Family Size											
	3	4	5	6	7	8	9	10	11	12+	Σ	%
1	1	6	8	12	8	10	1				46	27·9
2	1	1	5	5	4	5	3	1		3	28	17
3	1		1	5	3	5	2	1		2	20	12·1
4					4	6	3	1		3	17	10·3
5					1	7	2	1	1	3	15	9·1
6				1				1			2	1·2
7						1				1	2	1·2
8 +							1			3	4	2·4
Last	1	5	3	4	3	3	5			2	26	15·8
Only	5										5	3
Σ	9	12	17	27	23	37	17	5	1	17	165	
%	5·45	7·3	10·3	16·4	14	22·4	10·3	3	0·6	10·3		100

It is evident from Table II that there was a heavy representation of the first survivors (27.9%). Then in line came the second-survivors (17%) and the

last-survivors (15.8%). It is also obvious from Table II that there was a heavy representation of students from the families whose size was 8 (22.4%). It should also be borne in mind that there was an appreciable number of families (10.3%), probably joint families, whose size was 12 and more.

The paradox, that eminent scholars and scientists tend to be first-born or the only children, was only partially true in this study, because the representation of the only children was not in surplus and it was no wonder even if they represented overwhelmingly. Here again, I would like to say first survivor and not first-born because the first survivor will have the same advantages as the first born even if he is the second or third-born. Many scholars, who studied birth order and IQ, came out with diverse and even conflicting results. There is something special in the process of socialization of the first-survivors, the last-survivors and the only children. The father might want his eldest son to become an efficient breadwinner and take the responsibility of the family in his old age, and thus he tries his best to give higher education to his eldest son. If the size of the family goes on increasing, the father cannot afford to give higher education to all the children. Moreover, "......as family size increases, parental expressions of praise, approval, comfort and acceptance are likely to decrease in frequency per child."[5] That is, as the size of the family increases, the leadership becomes differentiated and thereby the process of socialization and social control become difficult. The same principle is applicable to the parents with only one child. The parents with only one child are more likely to give higher education to their child than those with many children. By the time the last survivors come for higher education there will be more than one earning person in the family and much less is expected of the last-survivors from the family, for the first-survivors will already be at work shouldering the responsibility of the family. Thus the last-survivors have better chances for higher education. Of the 26 last-survivors in the present study, 22 had highly educated and earning elder brothers or sisters, mostly elder brothers. Thus for various reasons, the first-survivors, the last-survivors and the only children have better chances than others to enter the portals of a university. So there is no wonder if there is a marked over-representation of first-survivors, last-survivors and the only children among eminent scholars and creative. cientists when they have better chances for higher educations It is, therefore, not mere chance but "simply a reflection of the fact that scholars, eminent or not, derive from a college population in which first-born are in marked surplus."[6]

EDUCATION AND OCCUPATION OF PARENTS

An attempt was made to find out the education and occupation of the students' parents and the person who had received maximum university education

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5 GLEN H. ELDER Jr. and CHARLES E. BOWERMAN, "Family Structure and Child-Rearing Patterns: The Effect of Family Size and Sex Composition," *American Sociological Review*, Vol. 28, 1963, p. 893.

6 STANLEY SCHACHTER, "Birth Order, Eminence and Higher Education," *American Sociological Review*, Vol. 28, 1963, p. 768.

in their families. In 72 families the fathers received maximum university education; in 42 families the elder brothers, in 11 families the elder sisters, in 9 families the mothers and in 31 families the students themselves received maximum university education.

TABLE III

EDUCATION OF PARENTS

Educational Groups	Fathers	Mothers
VIII Standard to Marticulation	24	54
Intermediate	12	17
B.A., B.Sc., etc.	29	5
B.A.B.L., B.T., etc.	23	3
M.B.B.S., etc.	25	4
B.E. etc.	17	—
M.A., Ph.D. etc.	19	7
Vernacular, nil, etc.	16	75
Total	165	165

It is obvious from Table III that the students' fathers were fairly educated. In the case of the students whose fathers were not well educated, their elder brothers and sisters received good university education. Thus " a student who comes of of a family where parents and near relatives are graduates, has, on the whole, better chances than a student who comes of a family where no one has entered the portals of a university. " [7] The higher the education of the parents the greater the goals set for their children. A student, in the course of our informal conversation, remarked :

" Immediately after my matriculation, my father, who is a farmer, wanted me to take to agriculture. But my educated elder brother who is working in a city took me to college, and as a result I am going to become an army doctor now."

Thus the education of the parents and near relatives plays an important role in an individual's educational achievment.

TABLE IV

OCCUPATIONS OF FATHERS .

Occupational Groups	No. of Fathers	%
I Agriculture	13	7·9
II Army Personnel	16	9·7
III Business Men	15	9·1
IV Higher Professional	46	27·9
V Lower Professional	5	3·0
VI Miscellaneous	70	42·4
Total	165	100

7 SIRSIKAR, V. M., " Social and Political Attitudes of Post-Graduate Students of the University of Poona, 1960-61," *Journal of the University of Poona* (Humanities Section), No. 17, 1963, p. 8.

First, an explanation of the occupational groupings employed here is in order :

I *Agriculture* : Farmers who cultivated their own or leased-in farms.

II *Army Personnel* : Mostly commissioned officers ranging from Brigadier to Second Lieutenant.

III *Business Men* : Mostly independent and substantial business men.

IV *Higher Professional* : Lawyers and Magistrates, Professors and Pricpals, Doctors and Engineers, etc.

V *Lower Prefessional* : Head-Masters, Teachers, Clerks, etc.

IV *Miscellaneous* : "Government servants" without any details, retired, deceased, uclassifiable, etc.

It is obvious from Table IV that only 7.9% of the students were drawn from the chief occupational pattern of the country viz. agriculture. More or less an equal number of students were drawn from army personnel and businessmen. Most of the students were the children of professors and principals, doctors and engineers and such other high professionals. Only 3% of the students were the children of the lower professionals. Of the 70 miscellaneous fathers, most of them were "Government servants" without any details; some of them were retired, deceased and unclassifiable.

Although the situation of the education of the students' mothers was encouraging, most of them were not gainfully employed except attending to their household duties. One of them was working as an Assistant Civil Surgeon; one was Reader in Physiology; two were Medical Practitioners; one was the Principal of a college; 8 were teachers and one was again a "Government servant" without any details.

FAMILY INCOME

Some students were reluctant to give the total annual income of their families. Some of them reduced the amount of their family income thinking that I might reveal the facts to the income tax office. Yet some others did so in the spirit of modesty and politeness. It must be recalled that many students, including some of the children of Government employees who had no other source of income, were sceptical regarding the exact annual income of their families. This kind of situation stems from many reasons. In Hindu social structure, the parents never discuss the revenue and expenditure of the family with their children. This is, perhaps, one of the culturally required conditions of Hindu parent-child relationship. One student said,

"My father never discusses the money matters of our family with me, nor he gives me an opportunity to know it."

Furthermore, the annual income of the family will be fluctuating according to the success or failure of harvest and business. Hence the following table

is subject to many such considerations and is quite likely to underestimate the annual income of the students' families.

TABLE V

Income Groups (In Rupees)	No. of Families	%
5,000 and below	39	23·6
5,001 — 10,000	47	28·5
10,001 — 15,000	33	20·0
15,001 — 20,000	10	6·1
20,001 — 25,000	6	3·6
25,001 — 30,001	3	1·8
30,001 and over	12	7·3
Not Given	15	9·1
Total	165	100

It is sufficiently clear that little over 75% of the students were drawn from the higher income strata. Education-higher, professional and technical in India-continues to be a costly affair and it is not within the reach of "common man" childern. Among the 15 students who did not give the annual income of their families, 9 students clearly stated that they did not want to reveal it and the remaining 6 students either left the column blank or stated that they were houestly ignorant of it.

Finally, an attempt was made to know whether the student came from a rural or urban area. Here again, only 47 students came from rural area, whereas 102 students came from urban area and 16 students did not answer the fixed alternative question — " Is your native place a taluka or district headquarters ? " Until very recently the attitude of the rural people toward education was that it was an upperclass institution. The present attitude of the rural people toward education is that it is a means for social advancement and prestige. But the urban people view it in a different way. It is a means for social advancement, prestige and income. It is enough for a rural parent if his son is in a town or city pursuing higher education. But an urban parent sends his son to technical and professional courses which lead to white-collar jobs.

CONCLUSION

If a similar research were to be conducted in an ordinary Arts and Science College, the social background of the students will be undoubtedly different. The educated parents are more likely to send their children to professional and technical courses which lead to white collar jobs. Their attitude toward education is different from that of uneducated perents. They place a very high value upon education

and education is a means to an end. To them, education is functional. So their action is instrumentally oriented. But to a typical farmer, education is not functional and it is not so meant for his son or, at the most, it is an end in itself. So his action is expressively oriented. He stresses farming as the main goal to his son. Most of the students in technical and professional colleges come from urban areas, because their educated parents happen to live in towns and cities. The same is true with socially advanced and wealthy parents. Thus the educational achievement of an individual depends mostly upon the position of his family—social, educational and economic.

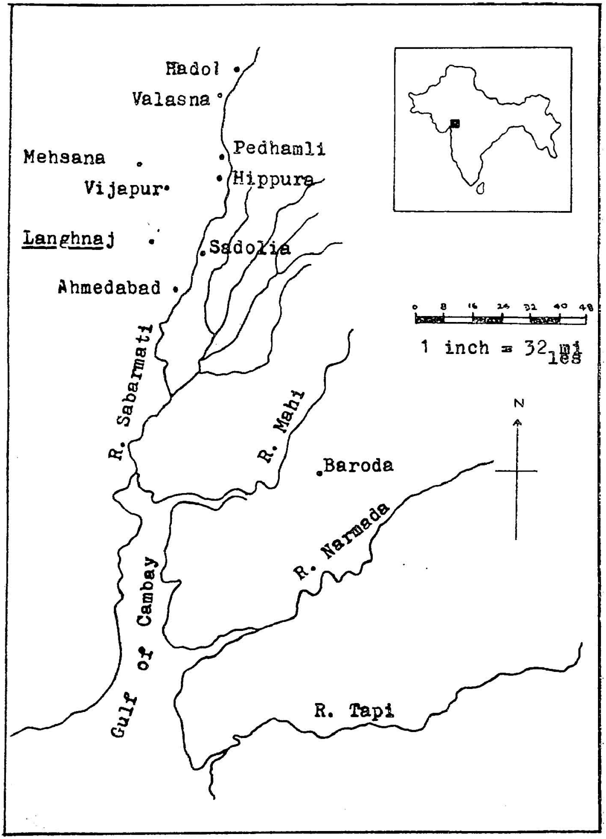


Fig. 1. The Location of Langhnaj in Northern Gujarat.

PRELIMINARY REPORT ON LANGHNAJ

THE PRELIMINARY REPORT OF THE 1963 ARCHAEOLOGICAL EXPEDITION TO LANGHNAJ, NORTHERN GUJARAT.

by

G. KARVE-CORVINUS & K. A. R. KENNEDY

This is a preliminary report of the archaeological excavation at Langhnaj which was directed by the authors in November and December of 1963. The expedition was made possible through the cooperation of the Departments of Archaeology of the Deccan College Postgraduate and Research Institute, Poona, the University of Baroda, and the Government of Gujarat, Rajkot. Confirmation or modification of the interpretation of the recent data from Langhnaj is dependent upon a thorough examination of the artifacts and osseous remains. Until this laboratory study has been completed, the impressions of the officers-in-charge stand on the basis of their field observations. The importance of Langhnaj to the prehistoric archaeology of Western India is emphasized by the fresh evidence now made available to scholars concerned with the development of early cultures in the Sub-continent.

The first discoveries of prehistoric stone tools in Gujarat were made by Robert Bruce FOOTE.[1] In 1893 he found a flake tool and two handaxes in the bed of the Sabarmati River near the villages of Sadolia and Pedhamli. Although these tools were the centre of interest to prehistorians gathered at the Geological Section of the British Association at Oxford, some fifty years elapsed before the artifacts were figured and described in a published account by Dr. H. D. SANKALIA[2]. This scholar again drew attention to the prehistory of this portion of India in his report of a programme of archaeological research in Gujarat initiated in 1941-the First Gujarat Prehistoric Expedition.[3] It was during the investigation of the sandy deposits in the vicinity of Vijapur that SANKALIA and his colleagues made their headquarters at the village of Langhnaj in the District of Mehsana, for this place offered them the convenience of a Government Rest House. Before the termination of the 1941 season of site surveying, it was observed that the mound upon which the Rest House stood, and which was cut by the road leading to the village, was microliferous and a repository of splintered bones. Further searching in the neighbourhood revealed that the mound which promised the greatest archa-

1 FOOTE, R. B., *The Foote Collection of Indian Prehistoric and Protohistoric Antiquities in the Government Museum Madras : Notes on Their Ages and Distribution*, 15, Madras, 1916.

2 SANKALIA, H.D.Pre-and Proto-History of Gujarat, *The Glory that was Gujaradesa*, 1.13-26, 34-40, 1943.

3 SANKALIA, H. D., In Search of Early Man Along the Sabarmati, *JGRS* 75-8, 1942; *Investigations into the Prehistoric Archaeology, Being the Official Report of the First Gujarat Prehistoric Expedition* 1941-42, Baroda, 1946.

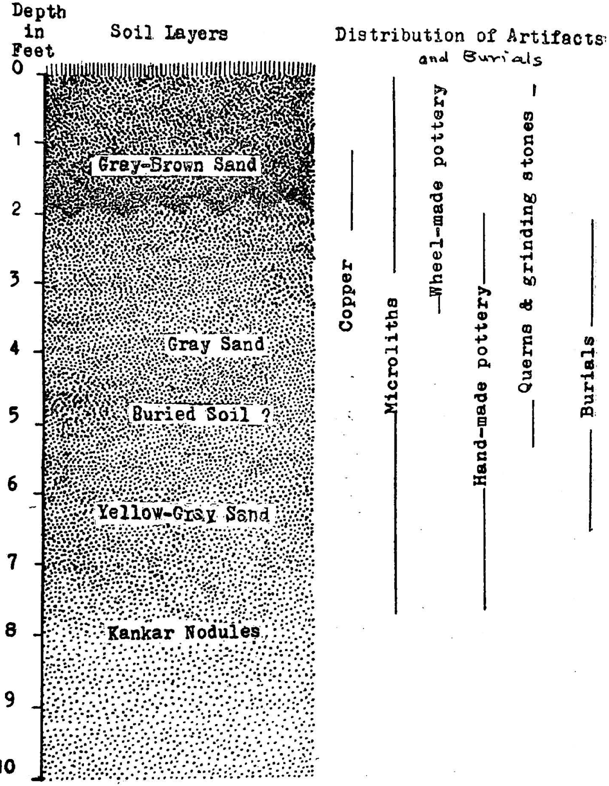


Fig. 2. Schematic Representation of Sectional Trenches at Andhario Timbo.

eological rewards was a large *timbo* rising to a height of some sixty-seven meters to the East of the Rest House-the *Andhario Timbo* (Fig. 1). Since the investigations of 1941, SANKALIA and his colleagues conducted a Second Gujarat Prehistoric Expedition in 1944[4], and a Third one in the year following.[5]. Subsequent work was conducted in this region in 1947 and 1949[6]. Dr. B. SUBBARAO continued excavations from 1952 to 1954[7]. The last expedition before the one described in this report took place in 1959[8].

Archaeologists have been faced with three major problems in their interpretation of the data from Langhnaj: (1) the identification of geological and palaeontological deposits in the sandy soils, as revealed along the walls of excavated sections and in eroded nalas; (2) the identification of cultural horizons with possible stratigraphic layers, i.e. the correlation of cultures with soils and fauna for different depths; (3) the absolute and relative dating of the site itself.

The problem of geological stratigraphy at Langhnaj was investigated by Dr. F. ZEUNER[9] who came to Gujarat in 1949. After examining the areas around the Sabarmati and Langhnaj, he defined a number of climatic periods with which he correlated specific kinds of soil deposits in this region. A humid phase (T), during which time the " red soil " which can be seen along the cliffs of the Sabarmati was formed, was followed by a main dry phase (U). In this latter period thick deposits of windborne sands were laid over great parts of Gujarat. These sands were ultimately transported by the rivers as an erosional material acting upon the granites and quartzites of the highlands to the North. ZEUNER assumed that at the termination of this dry phase a flat land surface was derived from subarial forces. Upon this ancient plain (V) another dry phase was active. Winds blowing from the southwest in the region of the Bay of Cambay led to the formation of the dunes. *Andhario Timbo* is one such dune (Plate I). These dunes were accompanied by blow-outs which became filled with water. The waterpan to the southwest of *Andhario Timbo* today serves as a village tank. From these depressions the materials which constitute the mounds were removed, and ZEUNER identified this dune phase (W) with the light yellow-grey, calcarious sand filled with kunkar nodules to be found at depths below five feet in sections of the site. The dune phase was followed by more humid conditions during which time vegetation gained a hold on the surfaces of the dunes and formed a soil cover (X). It was at this level of the " buried soil " that ZEUNER associated the cultural and osteological

4 SANKALIA, H. D., KARVE, I., The Second Gujarat Prehistoric Expedition : a Preliminary Account of the Search for; ' Microlithic Man ' in Gujarat, *NIA* 7·1·1–6, 1944.

5 SANKALIA, H. D., KARVE, I., *Preliminary Report on the Third Gujarat Prehistoric Expedition*, Poona, 1945; Early Primitive Microlithic Culture and People of Gujarat, *AA* 51·1·28-34, 1949.

6 SANKALIA, H. D., Stone Age Cultures and Climatic Phases in Northern Gujarat, *PISC* 3. Abstracts. 212, 1950.

7 SANKALIA, H. D., Excavations at Langhnaj, Gujarat, *Man* 55.33.26, 1955; The Microlithic Industry, of Langhnaj, *JGRS* 18-4-275-84, 1956; SUBBARAO, B, *The Personality of India*,[2] 69-75 Baroda, 1958.

8 REPORT Unpublished

9 ZEUNER, F., *Stone Age and Pleistocene Chronology in Gujarat*, 23, Poona, 1950.

remains of the prehistoric people of Langhnaj. During this occupation phase, the climate became drier and windborne sands were again deposited (Y). This was a brief period and the modern brown calcarious sands which constitute the upper three feet of the site (Z) cap this grey-brown layer. Today the region is again lightly wooded.

The mammal bones collected at Langhnaj prior to 1963 have been described by Dr. J. CLUTTON-BROCK[10]. She writes that it has not been possible to gain any information about the stratification of the faunal remains because the depths of the bones were measured from the uneven surface of the mound and not from the level of the " buried soil ". No single species appears to be correlated exclusively with either the upper or the lower layers. The precise faunal pattern during the period of prehistoric human occupation remains unclear. CLUTTON-BROCK has identified ten mammalian species among those specimens sent to London for palaeontological study :

" *Order Carnivora*

Canis cf. *lupus pallipes* Sykes 1831, the Indian wolf.

The left maxilla and mandible of one individual.

Herpestes edwardsi cf. *ferrugineus* Blanford, 1874, the Indian grey mongoose.

One almost complete skull and skeleton.

Order Perissodactyla

Rhinoceros unicornus L., the great one-horned rhinoceros.

Two scapulae, one humerus, one talus, and a molar tooth.

Order Artiodactyla

Sus scrofa cristatus Wagner, 1839, the Indian wild boar.

One talus and teeth.

Axis axis Erxleben, 1777, the spotted deer.

Four tali, teeth and antler fragments.

Cervus duvauceli Cuvier, 1823, the barasingha or swamp deer.

Five tali and teeth.

Boselaphus tragocamelus Pallus, 1766, the nilgai.

Five tail, four metapodial bones, two horn cores and teeth.

Bovini of Simpson, 1945.

Forty teeth and a large number of bone fragments.

Antilope cervicapra L., the blackbuck.

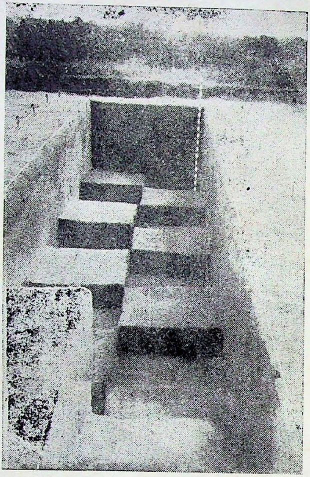
One talus, teeth and mandibular fragments. "

These faunal species can be found today in the savannah areas of the Indian Peninsula, although *Rhinoceros unicornis* is no longer in Western India and certain other forms are nearly extinct or of a very limited distribution. *Rhinoceros unicornis, Sus scrofa cristatus* and *Cervus duvauceli* and *Axis axis* are swamp-living

10 CLUTTON-BROCK, J., *Faunal Remains from the Microlithic Site of Langhnaj, Gujarat*, Unpublished MSS. The authors are indebted to Dr. CLUTTON-BROCK for permission to cite this report.

Plate I. The Crest of Andhario Timbo, seen from the West.

Plate II. The main Trench (Trench I) on the Crest of the Hill.



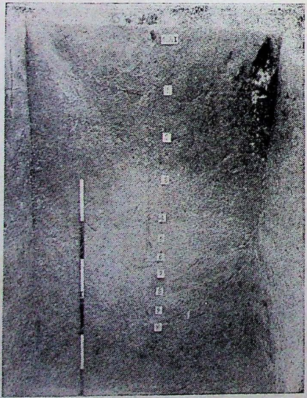


Plate III. Trench I, Section, facing East.

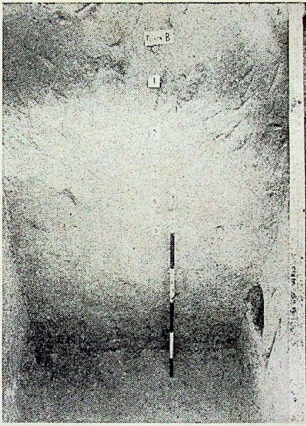


Plate IV. Trench B, Section, facing East.

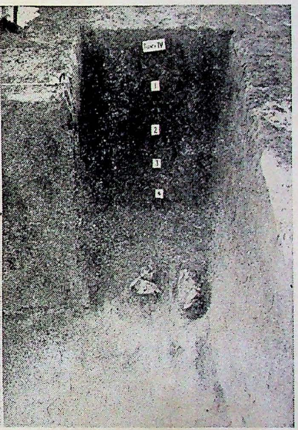


Plate V. Trench IV, Section, facing East with a pile of fractured Bones.

Plate VI. Fractured Bones from one of the piles.

Plate VII. The Copper Knife of Trench I. (Reduction; Approx 2 times.)

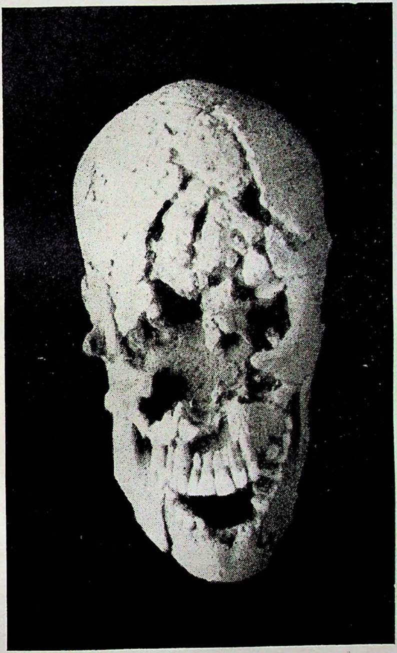


Plate VIII. Frontal View of the Skull.

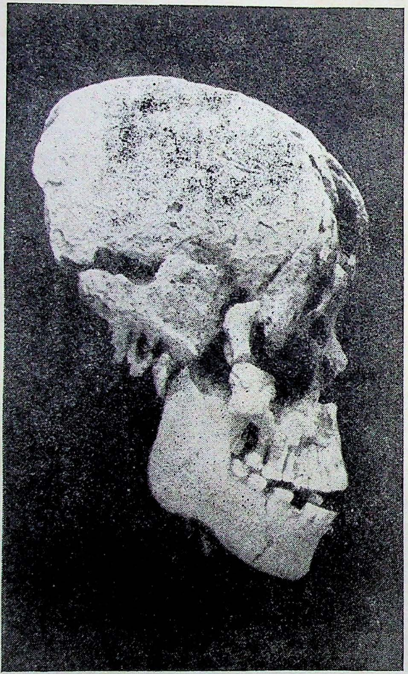


Plate IX. Lateral View of the Skull

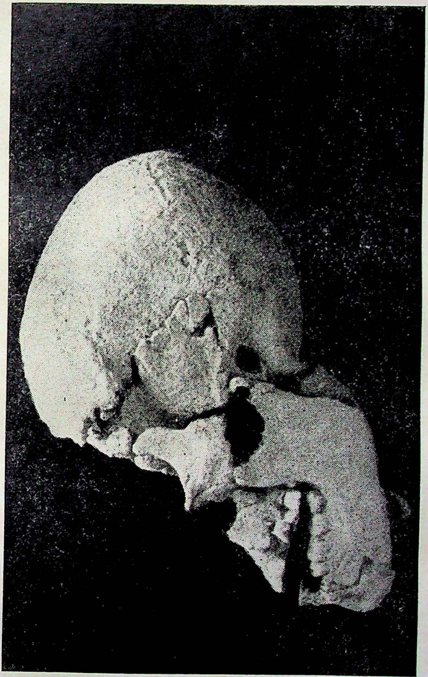


Plate X. Lateral View of the Skull

animals, and their presence at Langhnaj suggests that perennial water was available in Northern Gujarat during this period.

According to CLUTTON-BROCK the bovines from Langhnaj are difficult to identify. They do not seem to belong to *Bos gaurus* and *Bos indicus*. The latter was known at Mohenjo-daro, but not as a wild form. There is not enough comparative material to assert that the Langhnaj bones are *Bubalus bubalis*, although CLUTTON-BROCK thinks that *Bubalus bubalis* specimens in her collection come nearest to resembling them.

The second problem that Langhnaj presents—the relationship of one or more cultural horizons to the so-called stratigraphy—is a more complex one. There can be no doubt that the upper three feet of the site-ZUNER's Layer Z-contain the cultural remains of Neolithic and Iron Age occupations. These are recognized by the presence of pieces of iron slag and fragments of modern wheel-made pottery which has been well fired. Presumably the associated mammal bones are of domesticated species. As in the sands of Layer Z, the layer underlying it contains great numbers of microliths. But when the excavator descends to depths greater than three feet, the microliths are found associated with hand-made pottery of a cruder type. These lower sherds are dull brown in color with rough and poorly fired cores. Such coarse ware is no longer made in Western India.

Penetration into the deeper layer of the so-called " buried soil ", some four to five feet from the surface, revealed to the former investigators of the site a situation in which the microliths continued into a layer devoid of pottery. SUBBARAO[11] later pointed out that at this position some crude pottery could be associated with the stone tools, but SANKALIA and KARVE[12] had earlier suggested that only stray sherds from upper levels could be found in the pure microlithic layer under these circumstances. Here is a crucial problem, for upon the tenet that pottery is not an intrinsic feature of the " buried soil " has rested the assumption that Layer X contains the vestiges of a Late Stone Age culture over which had been superimposed a later pottery-using Neolithic and Iron Age cultural sequence.

Little help in the resolution of this difficulty can be sought in the examination of the other specimens of material culture found within the mound. Immediately below the layer containing wheel-made pottery and iron a quartzite macehead, or possibly a weight for a digging-stick, had been discovered along with two pieces of chlorite shist in the form of Neolithic celts, and some *Dentalium* shell beads. Layers below four feet have yielded a small number of sandstone querns and abrasive tools of the same material, implements used perhaps in the grinding of wild seeds and grains. Splinters of mammal bones which appear to have been used as tools were also recovered from these lower layers. But there is no distinctive feature of this artifact assemblage collected prior to 1963 to justify the theory that the lower deposits of the site contained the vestiges of a Late Stone Age culture. The absence of any stone tool larger than microliths and rubbing

[11] SUBBARAO, B., *The Personality of India*², 73-74, Baroda, 1958.

[12] SANKALIA, H. D., KARVE, I., *Preliminary Report on the Third Gujarat Prehistoric Expedition*, 2, Poona, 1945.

stones as well as the abundance of microliths does require the archaeologist to set a lower limit on the cultural period, however: the occupation must be post-Middle Stone Age.

SUBBARAO[13] claims that 87·4 per cent of the total number of microliths in the excavated sections lie below the level of the " buried soil ". However he marks the depth of this humid horizon within a range of from two feet ten inches to four feet two inches. Since microliths are found as deep as nine feet, this would mean that the lower two-thirds of an excavated section contain the majority of these tools, a situation that is not unexpected. The microliths that have been found at Langhnaj belong to a crude geometric industry represented by a high frequency of lunates and crescents and fewer numbers of triangles, trapezes, side and end scrapers and core scrapers. Some asymmetrical points may have been hafted to arrow shafts or used as barbs. A *Rhinoceros* scapula found by SANKALIA exhibits a series of cuts and abraded grooves which ZEUNER[14] interpreted as scars placed on the bone as a result of its use as an anvil in the manufacturing of microliths.

It has been assumed that all the human skeletons recovered from Langhnaj are from the same temporal period. This contemporaneity was suggested by the similarity of mode of burial, the concentration of the burials within an area of some sixty-five by thirty-five meters, the common association of skeletons with faunal remains of a similar degree of mineralization as well as their association with microliths, and finally the existence of anthropometric and morphological affinities between different individuals of the human skeletal series. Pottery was not reported from the layers in which the burials occur. Hence these skeletons came to be regarded as the vestiges of the manufacturers of the microlithic and pre-pottery culture which was called Late Stone Age.

If there were supportive evidence to show that the pre-ceramic layer was Late Stone Age, and if the burials could be intimately associated with this culture, then the Langhnaj skeletal series is the most ancient collection of human remains yet found in the Indian Sub-continent. There is only one other site in this part of Asia where human skeletal material has been found in association with a pre-agricultural and pre-metal using culture. These burials are found at Bellan Bandi Palassa[15] in the jungle of southcentral Ceylon. But radiocarbon dates for the culture of the Balangodese indicate that their Late Stone Age culture was quite recent, a survival of a microlithic culture well within the Historic period on the Island, i.e. within a few centuries before and after the birth of Christ. Was their culture contemporary with that found at Langhnaj ?

Opinions have differed widely concerning the relative and absolute chrono-

13 SUBBARAO, B., *The Personality of India*², 78, Baroda, 1958.

14 ZEUNER, F., The Microlithic Industry of Langhnaj, Gujarat, *Man* 52.182.129-31, 1952; *Environment of Early Man with Special Reference to the Tropical Regions*, Maharaja Sayajirao Memorial Lectures 1960-61 3-21-22, Baroda, 1963.

15 The anthropometric and biochemical report of the prehistoric skeletons from Bellan Bandi Palassa has been prepared by one of the authors and (K.A.R.K.) is now in process of publication.

logies of Langhnaj. SUBBARAO[16] turned to the evidence from other sites when he was unable to admit the presence of a true stratigraphic superimposition in his excavated sections. He noted that at Ranganathao there is a microlithic horizon which underlies an Harappan occupation. This site became the lower limit of his relative chronology . A second limit was found at Baroda where a clean and barren horizon intervenes between a microlithic and Early Historic layer. The upper limit was found at Timbarva where an Early Historic culture phase follows without hiatus an earlier occupation marked by the presence of Northern Black Polished Pottery (NBP ware). Since microliths are ubiquitous in the vicinity of Timbarva, SUBBARAO concluded that the microlithic phase could not be later than 400 B.C., the date assigned to the dawn of the Early Historic phase at Timbarva. SANKALIA[17] has looked to Rangpur and Rojadi for a correlation of their microlithic techniques with those practised at Langhnaj, evidence which has led him to favour a date of about 2500 B. C. as a lower temporal limit for the site. For ZEUNER[18], who does discern a distinction between the earlier pre-pottery microlithic users and their Iron Age successors who also manufactured microliths, the lower cultural horizon should be assigned a comparatively early date, but the Iron Age phase is given an antiquity not exceeding 2000 years B. P. Other dates which have been suggested for Langhnaj are 12,000 years B.P.[19] and one millennium prior to the Harappan Civilization, i.e. about 3500 B.C.[20] Such are the problems and theories that the present investigators have inherited from earlier workers at Langhnaj.

The expedition of 1963 was motivated by three objectives. The first was an effort to amplify the data already collected during previous excavations in order that the problems of stratigraphy, cultural horizon and chronology might be reassessed. This question of dating prompted the collection of bone samples from each of the levels of the sections excavated to a depth of ten feet from the surface. This was the second goal of the investigation. Finally, the party was interested in recovering additional human skeletal material which might assist in a reevaluation of the thesis that the burials are Late Stone Age in date and contemporary with the artifacts associated with them and this cultural period. The remainder of this report is concerned with the results obtained from the pursuit of these aims.

Eight trenches were excavated, four on the crest of the mound and four on the slope to the North-West and the South-West. This is the area of the mound to the East of the trenches which had been dug during previous seasons. The main trench on the crest was two by eight meters in size (Plate II). The other trenches had dimensions of two meteis square, save for one on the northwestern slope which

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16 SUBBARAO, B., *The Personality of India*², 74-75, Baroda, 1958.

17 SANKALILA, H. D., *Prehistory and Protohistory in India and Pakistan*, 146, Bombay, 1962.

18 ZEUNER, F., *Prehistory in India :-Four Brodcast Talks on Early Man, Deccan College Handbook Series* 1. i-ii, 1-7, Poona, 1951.

19 NAUDOU, J., Le Neolithique de L'Asie Meridionale, *L'Homme avant L'Ecriture*, edited by A. Veragnac, 11.315-39, Orleans, 1959.

20 GORDON, D. H. *The Prehistoric Background of Indian Culture*², 34, Bombay, 1960.

was two by four meters in size. Excavation proceeded by a system of " sub-squares" each one meter square for the levels of a given trench. Excavation terminated at the ten feet level for six of the eight trenches, but for two on the slope of the mound digging was continued only to depths of three and six feet respectively.

The distribution of these eight trenches at different loci on the mound afforded the researchers an opportunity to check the presence or absence of stratigraphy. Such very specific climatic fluctuations as ZEUNER has defined would suggest that traces of humid and dry phases might be clearly visible in the pit sections. Yet to the eyes of the present investigators only two, or at most three, soil layers are discernable (Plates III-IV). The geological stratigraphy as observed by us in the sections of the trenches is depicted schematically (Fig.2). There is a dark grey-brown topsoil which extends from the humus line to a depth of about three feet. Beneath this is a layer of lighter grey sand which merges at a depth of about five feet with a grey-yellow calcarious sand where one encounters kunkar nodules of various sizes. No traces of the so-called " buried soil " could be detected, although the presence of *Rhinoceros* bones and the remains of other swamp-living animals in the habitation layers of the site suggest a humid climate and a forested country-side during the time these fauna and their hunters were occupying the region.

Microliths are ubiquitous in the different layers of the mound. True micro-lithic tools with evidence of retouching constitute less than two to five per cent of the total number of microlithic flakes collected. Lunates, crescents, trapezes, triangles, points and " plunging flakes " are present. Nodules and cores range in size from minute pebbles to fist-size stones. Quartz and varieties of chalcedony are the common raw materials. Until the microlithic collection has been carefully studied in the archaeological laboratory, it is not possible to determine what the distribution of these types may be within the mound.

In all layers pottery is present. Where sherds are absent, microliths are also scarce or absent, as at depths under seven feet. Here faunal remains decrease in frequency as well. Therefore the present excavators cannot confirm the statements of earlier researchers that a pottery-free microliferous zone underlies a pottery-bearing layer, although this is not to question the existence of such a situation in the trenches previously excavated. As SUBBARAO[21] has noted in the description of his work, the pottery of the lower levels is characterized by its coarseness and poorly-fired condition, while the wares of the upper level are better made as a result of superior techniques of firing and modelling. Sherds of the crude hand-made pottery are smaller than pieces of wheel-made manufacture, and no rim pieces of the former type are found at depths below three feet.

Ground stones of granite and sandstone have been collected from depths of two to six feet. These may be the parts of querns used for the grinding of grains and seeds. Although a complete quern has yet to be found, it may be possible to reconstruct the original form of one of these implements from recovered bits of rims and one saddle-shaped mid-section. Ground stone pebbles in the vicinity

21 SUBBARAO, B. *The Personality of India*², 74 Baroda, 1958.

of these larger fragments may be the pounders or rubbing stones held in the hand when materials were pulverized on the querns.

Two beads of *Dentalium* shell and one flat stone bead were found at two to three feet from the surface in a trench along the slope of the mound. These were in direct association with the human skeleton recovered from this zone.

In previous excavations the only metal objects found were bits of iron slag of obviously recent or Iron Age times. Iron was again found in the course of the present work at Langhnaj, but now for the first time copper has been discovered there. A knife of pure copper came from a depth of three feet two inches in the long trench at the crest of the mound (Plate. VII). The implement measures thirty centimeters in length and has a width of two and one half centimeters. Its blade has preserved a sharp edge, and the dull half of the implement strongly suggests that it had been hafted to a material which has now disintegrated. The stylistic comparison of this knife with similar tools in the Chalcolithic and Bronze Age sites of India and the Near East may provide additional clues to the antiquity of the culture of Langhnaj. Two other pieces of copper were found together at a depth of six inches from the surface in one of the trenches on the slope, but the affinities of these scraps with the copper knife may not be significant.

In contrast to the great number of microliths and potsherds found in the site, the frequency of faunal remains is low. All levels of the sections have rendered small splinters of bone, but the identification of these according to species is extremely difficult. Cranial portions and teeth are represented by only ten fragments. One molar tooth and the distal end of a femur appear to belong to *Rhinoceros*. Bovines are represented by the proximal end of a tibia, tarsal and carpal bones, a few pieces of the dentition, and two vertebrae. Tarsal and carpal bones of deer, the canine tooth of a dog or wolf, and some twenty-five pieces of tortoise carapace are in the series. Snail shells of conical and helix forms are encountered at all depths down to ten feet. The post-cranial skeletons and mandibles and maxillae of small rodents which have been uncovered have no doubt become incorporated in the site as a consequence of the fossorial habits of these animals, their bones appearing to be quite fresh. All of the other bones in the collection are heavily incrusted with a deposit of calcium carbonate. Their condition may be described as sub-fossilized, for the compact and cancellous tissues themselves are not in all cases mineralized.

An interesting feature of the larger bones is their assemblage in two heaps some twelve feet apart and at a depth of five feet (Plate. V). These are limb bones and they appear to have been fractured by man, perhaps for the extrication of the marrow (Plate. VI). The piles of bones do indeed suggest the refuse from a feast. Into the proximal end of a tibia a neat hole has been bored. Both piles of bones are surrounded with a fine "gravel" consisting of rounded quartz grains, nodules of kunkar, laterite pellets, angular feldspar, and pieces of disintegrated granite. Most of the components of this gravel, except the kunkar and iron nodules, have their origin from granite, probably the granite which is found in the northern part of this Mehsana District. The

explanation for this accumulation of " gravel " around these piles of bones is not obvious. The absence of cranial bones here and at other loci of the mound suggests that the early hunters butchered their game at the place where it was slain, carrying the choice portions of the animals to the area of occupation. However, no hearths have been found during the past twenty years of work at the site, and the piece of charcoal discovered in 1963 is therefore of considerable importance for purposes of radiocarbon dating. The presence of querns in close proximity to the bones may mean that some food preparation did occur in this part of the site, inspite of the absence of hearths.

In lieu of a well defined stratigraphy, a specific taxonomic classification of the fauna and the certain identification of the cultural horizons, the relative chronology of Langhnaj can be determined by the biochemical analysis of samples of bone collected systematically from graduated levels of a deep section. Twenty-eight bone samples were collected during the recent excavation from the surface to a depth of ten feet. At least two bone specimens were secured from each layer. These samples are presently being tested abroad for their contents of nitrogen, calcium carbonate, iron, fluorine, and the phosphates. The interpretation of the test results will clarify the problem of contemporaneity between upper and lower levels of the site. The charcoal sample referred to above may assist in the absolute dating of Langhnaj. The biochemical assays of several osseous specimens sent earlier to the chemists have been reported[22], but these results remain inconclusive until they can be compared with the values to be obtained from the larger series collected in 1963.

Since the excavation of Langhnaj in 1944 some thirteen human skeletons have been found at depths ranging from two to six feet from the surfaces of the crest and the slopes of the mound[23]. The latest excavation has added another specimen to this number (Plates. VIII-X). The skeleton was found two feet two inches underground in one of the trenches along the slope of the mound. The shallowness of this burial does not signify necessarily that the skeleton and its associated

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22 Three bone samples collected during previous excavations have been sent to Dr. KENNELH Y. OAKLEY of the British Museum (Natural History), London, for biochemical assay. Since 1953 when these samples were studied, two others have been submitted in 1963. Dr. Oakley reports in a personal communication to one of the authors (K. A. R. K.) the following results : (1) the nitrogen content of two of the samples of human bone collected from depths of four feet and five feet seven inches are 0.40 and 0.10 respectively (percentage of nitrogen in 100 grams of ground bone sample); (2) fluorine assay of three other bone samples indicates a percentage of 0.03 for a cervid bone near the surface of the ground, 0.39 and 0.43 for cervid and hominid bones from the layer of the " buried soil "; (3) percentages of calcium carbonate for these same three samples are 10.0. 20.0 and 30.0 respectively. Fluorine and nitrogen percentages of these orders strongly suggest that the specimens are of post-Pleistocene date.

23 KARVE, I., KURULKAR, G. M., *Human Remains Discovered So Far : a Preliminary Report on the Human Skeletal Remains Found at Langhnaj in February and December* 1944, 4-19, Poona; KHAN, A. H., KARVE, I., Identification of a Few Bone Remains from Langhnaj, *Investigations into the Prehistoric Archaeology of Gujarat, Being the Official Report of the First Gujarat Prehistoric Expedition by H. D. Sankalia*, 1941-42, 313-14, Baroda, 1946; SANKALLA, H. D., KARVE, I., Early Primitive Microlithic Culture and People of Gujarat, *AA* 51.1.28-34, 1949; ERHARDT, S., Fruhmenschliche Skelette aus Langhnaj in Gujarat, Vorderindien, *ZMA* 54.2.151-62, 1963.

cultural and faunal remains belong to a cultural horizon which is later than that with which the other burials have become associated. Some of these earlier discovered skeletons came from layers only two feet deep. Furthermore, the slope is that portion of the mound most vulnerable to the ravages of weathering and erosion. Each year a film of top soil is removed from the slopes of the mound, but the crest supports a more stable ground cover. Like the other skeletons in the Langhnaj series, the bones of this recent specimen are coated with a rough mineralized concretion. Sub-fossilized bones are what may be expected when osseous tissue is buried in the kind of dry, sandy and calcarious soil found in this part of Northern Gujarat, and this condition is not in itself an indication of great antiquity for the skeletons. Bones of recently deceased domesticated cattle which were picked up from the surface of the mound revealed initial stages in this process of mineralization.

Some of the features of the new skeletal specimen are unique when compared with the earlier finds. The position of burial is dorsal extension, while the other burials from Langhnaj are in various attitudes of lateral flexure. While the skulls of the other thirteen specimens point to the East, the recent find has its head oriented to the West. Its face is turned slightly to the North and the left hand rests upon the left ilium. A *Dentalium* shell bead on the ilium and the faunal associations are the kinds of objects already observed in the vicinity of earlier finds. However, the new specimen is surrounded by fragments of both wheel-made and hand-made pottery. The possibility of these ceramic wares having been intrusive in the burial area cannot be ruled out of consideration.

While no pit line was discernible, it is obvious that this skeleton, as well as the ones discovered earlier, reveal the existence of true burial customs among the ancient inhabitants of Langhnaj. The authors do not support the view that these skeletons were thrown haphazardly into the ground subsequent to some battle or traumatic event as has been suggested by another researcher[24]. Nor can the fractures across the surfaces of the crania from Langhnaj be interpreted with any certainty to be the results of blows with heavy instruments. These cracks in the skulls, as well as in the post-cranial portions of the skeletons, are the natural consequences of the weathering of the osseous tissues within the microenvironment of the mound. If changes of temperature and humidity in the soil can effect the fracturing of stones buried for considerable periods of time, then human bone cannot be considered as exempt from these forces. Further destruction is due to the pressure of overlying layers of soil and the ravages of small animals and vegetation. One of the authors has observed many examples of this type of post-mortem bone damage in American Indian cranial and post-cranial specimens where it would be untenable to conclude that an untimely and violent death was met by the specimens in every case. For similar reasons the evidence for cannibalism at Langhnaj cannot be supported. Were these specimens the vestiges of unwilling participants in a cannibal feast, one would expect to find signs of a consistent method for fracutring the skulls prior to the extraction of the brain. But all portions of these skulls

24 EHRHARDT, S., Schlagspuren Bruche und Sprunge an den Skeletten von Langhnaj im nordlichen Gujarat, Vorderindien, *Anthr. An.* 24.2-3. 178-83, 1960.

have suffered breakage. The most efficient technique for taking the brain out of a fresh skull, as practiced by cannibals whose customs have been recorded[25], involves the cracking of the basalar and posterior portions of the brain case, for here the cranial architecture is weakest. Attempting to pull out the brain after breaking the frontal and parietal bones with their heavy tori and muscular attachments and architechtural solidity would be an unfair challenge to the heartiest of cannibalistic Epicurians.

The examination of the new skeletal material from Langhnaj is now in progress. Superficial observation indicates that the complete skeleton is that of an adult male of between twenty-five to thirty years of age at time of death. The post-cranial bones suggest that the stature of this specimen during life was well within the medium range for world populations today; about five feet five inches to five feet seven inches. The cranial bones are robust and the bones of the lower extremity indicate considerable muscular robusticity. Additional but incomplete human bones and some teeth were uncovered in adjacent trenches at depths from three o five feet, but these are too fragmentary to be anthropometrically rewarding.

Until the collections of cultural and osteological materials have been thoroughly studied in the laboratory, it is premature to formulate definite conclusions about the new evidence from Langhnaj. Therefore the following points must be considered as the bases for continued research and formulation of new questions concerning the place of Langhnaj in the prehistory of the Indian Sub-continent.

1. The geological stratigraphy of the site, as observed in all eight of the trenches excavated, reveals a dark grey-brown sandy soil extending from the surface o a depth of about three feet. This is succeeded by a layer of grey sand of lighte hue which merges with the calcarious and kunkar-filled deposits at a depth of five feet. The " buried soil " of which ZEUNER speaks was not visible to the excavators. Rather it was noted that the composition of the soils in the trenches examined is unmarked by any hiatus of a stratigraphic nature.

2. The problem of the existence of a stratigraphical sequence is of interest since it suggests to the archaeologist that if a " buried soil " is not present, then interpretation of the cultural horizons must suffer drastic revisions. The authors are unable to distinguish any horizon marked off by cultural content which can be exclusively identified with a Late Stone Age culture, although such layers have been described during previous excavations at *Andhario Timbo*. The only cultural change that is evident from scrutiny of these eight trenches is the change from modern wheel-made pottery in the topmost layer to the cruder, hand-made pottery of the underlying layer. Microliths are found at all depths. Where microliths decrease in quantity, so do the pottery and other cultural artifacts. Hence a correlation of geological stratigraphy with cultural horizons is unsubstantiated.

3. The chronological position of Langhnaj must be reexamined in the light of the discovery of copper, for this is the first evidence for early metals from this site. It may well mean that certain Late Stone Age cultural elements have been

25 VON KOENIGSWALD, G. H. N., *Meeting Prehistoric Man*, 75, Thames and Hudson, London and New York, 1956.

found in association with a tradition whose origins are Chalcolithic. On the other hand pottery can no longer be regarded as the hallmark of food-producing societies in the past. The association of pottery with Mesolithic and Late Stone Age cultures in Europe, Africa and Southeast Asia indicates that its invention preceded the abandonment of the hunting-gathering way of life in many regions.

4. The skeleton appears to be contemporary with those burials which have been found since 1944, although certain features of the circumstances of burial are unique. Until the results of the biochemical analysis have been submitted, it remains uncertain whether these sub-fossilized specimens are related to the upper or lower levels of the mound. The absence of metals in association with the burials favors the traditional interpretation that these are the manufacturers of the early microlithic industry.

HOW MANY LETTERS DOES ONE RECEIVE?

(A case study of personal correspondence)

by
KAMAT A. R

INTRODUCTION

Communication by written word is as old as the use of script. But it is only in the modern society that written communication has assumed such an important part in the life of an individual. The spread of education (and of literacy in particular), better and cheaper facilities in the form of postal services for carrying the written word, large-scale production of cheap paper and the organisational form of the present society have contributed to this development.[1] Correspondence or communication by written word has now become a part and parcel of our individual and social life.

The present article is an attempt to study one aspect of personal correspondence - the correspondence (letters and other written forms of communications by post or by hand) received by a person. This is a case study. A kind friend[2] (who will, as is customary in a case study, remain anonymous and to whom we shall refer as Mr. X in the sequel,) agreed to fill a short schedule for every letter or other article of his inward (or in-coming) personal correspondence over a period of one year and thus provided us with valuable data. This data was analysed for its most important characteristics and the results are summarised in this article.

The usefulness of a case study is always rather limited when one attempts to draw from it inferences valid for a group. This is all the more so in the case of an activity like correspondence which, by its very nature, is bound to be of a highly individual character. Even so this study is presented here in the belief that it may throw some light on the structural character of personal correspondence of individuals belonging to a small but socially important group of intellectuals in our society.

CONCERNING MR. X

Before we describe the data collected it is necessary to state a few facts about Mr. X so as to provide the necessary personal, social and institutional background for the study. Mr. X, a person past middle age, is a fairly senior member of the teaching staff of an old and reputed college in Poona. (Poona is a well-known centre of education in the Maharashtra State in India.) His specialisation is in one of the science subjects and he had a part of his post-graduate education abroad

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1 In fact looking to the amount of paper used for communication and for record in our time the present age may well be described as the " paper age " of civilization !

2 We take this opportunity to thank him for his help and co-operation.

in a European country. As a senior teacher he participates in the post-graduate teaching programme of the Poona University in addition to his teaching duties in his college. In the capacity of a teacher he is an ex-officio member of certain university bodies. He guides a few students for research in his subject and as a research worker he is connected with a few learned societies and organisations Being a member of the board of management of the college Mr. X has also to participate in the administrative duties of the college.

Mr. X is married and has a family, and he belongs to an advanced community. He had no special moorings or connections in Poona (except as a student in his youth) before he joined the teaching staff of the college. He has a few friends but in his own words he is not " a social hit ". Consequently he does not have a wide social circle and does not lead a busy " social life ".

DESCRIPTION OF DATA

For the sake of exactness only written communications addressed to Mr X were considered for this study. Thus oral messages, telephone calls etc. were not included. Secondly, the study confines itself to only those communications which were addressed to him by name and not merely by designation (e.g. "Professor of XXX, XXX college "). Thirdly, only those communications were included which (wholly or in part) remained with Mr. X. Thus circulars or circular invitations (on which he signed in token of his having read them) but which did not remain with him were not included in this data. Communications addressed to Mr. and Mrs. X were included but those addressed exclusively to Mrs. X or to other members of his family were not covered by this study. It is possible that a few communications of a casual nature and delivered by hand may have been inadvertently escaped notice. But Mr. X assures us that their number would be very small-not more than 10-over the course of the year. The data therefore cover *all* postal deliveries and most of the communications delivered by hand. It should be repeated that only the in-coming correspondence is considered; the outgoing correspondence is not considered except indirectly when it was in reply to the inward correspondence.

The following items were recorded for each of the communications received : (1) Date of receipt, (2) Time of the day of the postal delivery, (3) Name of the sender, (4) Address of the sender, (5) Date of despatch, (6) Type (postal) of the communication, (7) Value of stamps (in case of postal articles), (8) Nature of the contents, (9) Whether the communication was at the initiative of the sender or otherwise, (10) Whether a reply was expected, (11) Whether a reply was sent, (12) Date of reply, (13) Type of the reply communication, (14) Value of stamps for the reply communication if sent by post and (15) the probable value of stamps which would have been required if the reply were sent (but was in fact not sent).

For the particular category of communications which were invitations to meetings, lectures, social functions, etc. the following additional information was listed : (16) Nature of the occasion, (17) Whether invited alone or with wife or family, (18) Whether attended, (19) Time spent over the function if attended, (20) Money spent on transport for attending it, (21) Time which would have

been spent if it were attended (when in fact it was not attended,) and (22) Money which would have been spent on transport in that case.

The data was then coded and put on punched cards for analysis.[3]

Over the period of one year, Mr. X received 703 communications out of which 147 were delivered locally *by hand* and 556 were received through the postal services. The latter included 2 telegrams, 20 express delivery letters and 534 postal articles by the normal deliveries. (There are three normal deliveries in Poona). This is summarized below :

	By Post					
Total	1st delivery	2nd delivery	3rd delivery	express delivery	Telegrams	By hand
703	287	150	97	20	2	147

It is interesting to note that commnications by hand constitute a sizeable fraction, 21 per cent, of the total number of communications.

Different Roles of the Intellectual

Before we make an attempt to structure the in-coming correspondence of Mr. X it is perhaps useful to delineate the different roles which an intellectual (in general and of Mr. X's profession in particular) has to fulfil since the structure of his correspondence will be closely related to them. (1) First, the intellectual is a member of his family and kin group and as such he has certain obligations towards this group. (2) Secondly, he has his *professional* duties and obligations. For the intellectuals of Mr. X's profession they will consist of (a) routine teaching and institutional work, (b) research work and (c) examination work. (3) Finally, the intellectual has also to play (what may be described as) *social* roles. These may be broadly characterized as follows. (a) In the first place he will have his group of friends and close acquaintances. Perhaps the obligations towards this group and the resulting correspondence may resemble in their character more to those relating to his kin group than to the other groups. (b) Then, he has to play the social roles as member of other social groups because of his profession. For instance he may be invited to a social gathering of another college or to attend the wedding of a colleague's daughter. Although both the invitations arise out his professional contacts it is clear they are different in character. (c) Lastly he may have social roles to play towards non-professional groups. For instance he may be a member of a club or an association not connected with his profession.

Of course there may be a certain amount of overlapping between these several roles of the intellectual. But broadly speaking they would conform to the pattern outlined above.

[3] There was one communication (from a government organisation) where the cover was addressed to Mr. X but the contents were addressed to another person ! This was excluded.

STRUCTURING THE CORRESPONDENCE

We will now try to structure the in-coming correspondence of Mr. X. For this purpose the communications are first classified by their contents. To start with three broad categories were conceived : (I) Personal communications of a private nature, (II) Professional communications, and (III) Invitations The first category could be further sub-divided into (IA) communications from his family and kin group or about matters pertaining to the family and the household, and (IB) communications from his friends and close acquaintances. This sub-division will then correspond to his roles towards his kin group and the group of friends and close acquaintances respectively. The second category can be further usefully sub-divided into : (IIA) communications connected with the routine teaching and administrative work of Mr. X, (IIB) communications about other academic work such as research work and membership of learned bodies, and (IIC) communications about examinations in the Poona University or other universities where Mr. X acted as examiner. Category (III) was conceived separately to facilitate its further detailed analysis given in later sections below. But a portion of them could in fact be distributed over (IA) and (IB).

Perhaps description of each of these categories in a little more detail may be helpful in clarifying certain points. For instance, categories (IA) and (IB) cover letters from family members who are away, relatives, friends and acquaintances, business communications (e. g. life insurance) relating to Mr. X and his family, and magazines or periodicals not connected with Mr. X.'s profession. Category (IIA) includes communications about routine teaching and administrative matters in the college, communications from the Poona University bodies, requests for references or certificates from students, communications about text books, etc. Category (IIB) consists of communications about research work of Mr. X (and for its publication,) about research grants, reprints of research papers sent by others and also communications from the learned societies and conferences of which he is a member or a delegate. Category (IIC) is entirely correspondence received about university examinations either from the university concerned or from the examiner colleagues or other relevant bodies or persons. Category (III) includes all invitations to attend functions, lectures, meetings or other social occasions such as weddings and thread ceremonies.

It is necessary to point out here the difficulty of clear-cut classification. A friend may sometimes also be a colleague and relationship with a colleague or a student may sometimes develop into friendship and these things tend to blur the formal lines of demarcation between different types of relationships and therefore between the formal categories of communications described above. With this explanation we give below the following figures about the broad structure of these communications.

The outstanding fact which emerges from this analysis is that only a small fraction (twenty-one per cent) of the communications are of a really personal and private character. (This is not very much altered even if the invitations are further distributed into those arising from private and professional contacts or

TABLE 1 : STRUCTURE OF INCOMING-COMMUNICATIONS

Category	Number		Per cent	
IA	80	148	11·4	21·1
IB	68		9·7	
IIA	94	441	13·4	62·7
IIB	133		18·9	
IIC	214		30·4	
III		114	16·2	
Total		703	100·0	

occasions, as will be shown below.) An overwhelming part of the incoming correspondence (five out of every eight communications) is concerned with professional matters of which routine matters about the teaching and administrative duties account for 13.4 per cent, the non-routine matters (research) for 18·9 per cent and examinations account for 30·4 per cent (a little less than one-third of the total communications received).

One-sixth of the total communications received were just invitations. This indicates the important part they play in the present day social life. They are analysed for some of their interesting aspects a little later. Here it will be noted that out of these 114 invitations only 22 were from relatives, friends or close acquaintances; among the remaining there were 31 from colleagues and students, 35 from colleges and other institutions, 13 from other contacts arising out of his profession, and 13 more from non-professional contacts. If the 22 invitations from the first source are distributed over (IA) and (IB), 35 from colleges and other institutions are classified as (IIIA) and the remaining 57 under (IIIB), we get the new classifications more or less on the lines of the different roles which the individual of Mr. X.'s profession has to play (as stated in section 4 above). The structure of Mr. X.'s in-coming correspondence may therefore be presented in the following alternative manner.

TABLE 1—A : STRUCTURE OF INCOMING COMMUNICATIONS

Category	Number		Per cent	
IA	81	170	11·5	24·2
IB	89		12·7	
IIA	94	441	13·4	62·7
IIB	133		18·9	
IIC	214		30·4	
IIIA	35	92	5·0	13·1
IIIB	57		8·1	
Total	703		100·0	

Some Observations on the Contents

A few observations on the contents may be made at this stage. As seen

from Table 1 category (IA), only 11 per cent of the in-coming communications is related to the familty or kin group. Actually only 35 of those 80 communications were letters from the family or kin group, the rest of them being business communications (life insurance, bank invoices etc.) or magazines and periodicals which were for the benefit or use of Mr. X and his family. Most of the 35 letters were from brothers or sisters of Mr. X and were mainly concerned about ordinary family matters or events. From category (IB) which accounts for 10 per cent of the in-coming correspondence about half of them were from three or four close friends of Mr. X not connected with the profession,. Here the letters giving news about their families and mutual friends had the main objective to keep in touch as also to exchange views and opinions (in a casual manner) on current events. Occasionally, they had some specific objective as getting their wards admitted to the college. But the remaining half of these communications, from closer acquaintances, unconnected with the profession were very often concerned only about specific objectives such as securing a seat in college for a youngster, inquiries about academic openings or even inquiries about suitable match for matrimony. This again emphasizes how small is the magnitude of strictly personal correspondence.

Turning to communications connected with Mr. X.'s profession the relatively small number (13 per cent) of communications about the routine teaching and institutional work (IIA) may not appear to be commensurate with what is obviously the main activity of Mr. X. But it should be remembered that many communications in these matters would be very often oral or by circular both of which were excluded from this study which was confined only to written communications which remained with Mr. X. The second activity, research work etc. (IIB) accounts for 19 per cent of the communications. More than three-fourths of it was incidental to his research work in the sense that it included journals, routine communications from learned societies, requests for reprints, research grants from government and the university etc., the remaining (less than one-fourth) being directly connected with his work such as correspondence with colleagues or publication of his work. For many members of Mr. X.'s profession this activity would be entirely absent and the resulting correspondence would not exist. Nearly 30 per cent of the communications and almost half of those connected with his profession is taken up by examinations (IIC). This large number no doubt indicates the role of this activity in the life a senior college teacher like Mr. X. But as Mr. X mentioned to us the number of these communications possibly exaggerates its importance because a single university examination very often would mean more than 25 communications and sometimes upto 50. They include many routine circulars about dates, programmes, forms and what not. According to Mr. X, the large number of these communications reflects more the amount of paper-work and rigid rules involved in this activity rather than the actual volume of work involved or the amount of time devoted to it.

No observations are offered here on category (III) — invitations—of Table 1 since some of its details are already given above and some further analysis will follow later.

More Light on the Structure

Two aspects which throw further light on the structure are the postage involved and the classification by sender. The distribution of total postage over the categories IA, IB, IIA, IIB, IIC and III of Table 1 is given below.[4] (This necessarily excludes the 147 communications received by hand.)

TABLE : 2 STRUCTURE OF INCOMING COMMUNICATIONS (POSTAGE)

Category	Postage (in Rs.)		Per cent	
IA	11·50	22·87	5·1	10·1
IB	11·37		5·0	
IIA	14·52	200·54	6·4	88·4
IIB	37·04		16·3	
IIC	148·98		65·7	
III	3·34		1·5	
Total	226·75		100·0	

A few explanatory observations may be offered. The bulk of the total postage of Rs. 226.75–two-thirds of it–is on (IIC) that is on communications about examinations. This is due to the fact that they included many registered letters and parcels which are relatively costly communications. The postage on category (IIA) was low because many of them were locally delivered by hand and not through post. The same is the case with (III), invitations. Only 41 of them came by post and they were often book-posts costing very little postage per communication.

Classification by sender given in Table 3 also confirms the structure of incoming communications exhibited above. Private contacts (family members, relatives, friends and acquaintances) do not account for more than 15 per cent

TABLE 3 : SENDER

		Total	Marathi	Invitations
1.	Family members and relatives ...	35	14	1
2.	Friends	36	13	4
3.	Acquaintances	32	16	17
4.	Colleagues in college, or university ...	35	22	23
5.	Students past or present	35	21	8
6.	College office, college authorities, etc.	31	4	12
7.	Poona University, other colleges, etc.	125	—	20
8.	Other universities and similar institutions	179	—	2
9.	Learned societies, conferences, journals, etc.	60	4	1
10.	Miscellaneous	135	37	26
	Total	703	131	114

4 Two letters received were underpaid for which Mr. X had to pay 0·20 of a Rupee.

of the total communications. Even when colleagues and students are included (the outermost circles of personal contacts) this does not cover more than 25 per cent. More than three-fourths of the correspondence is from institutions and institutional contacts and most of them connected with the profession which Mr. X is pursuing.

OTHER ASPECTS

Other items of interest will now be considered. Classification by sender's address is given in Table 4. It should be mentioned that at the time of the study the Bombay State consisted of Western Maharashtra, Marathwada, Nagpur and and Vidarbh areas and Gujarat. About 40 per cent of the correspondence was local and 55 per cent confined to the two cities Poona and Bombay. The former Bombay State accounts for almost three-fourths of the in-coming communications.

TABLE 4 : SENDER'S ADDRESS

	Total	Marathi	Invitations
1. Poona (local)	277	66	92
2. Bombay City	110	23	6
3. Western Maharashtra (excluding 1, 2)	54	27	13
4. Bombay State (excluding 1,2,3) ...	79	2	—
5. India (excluding 1,2,3,4)	114	6	3
6. Abroad	69	7	—
Total	703	131	114

This concentration in inner geographical circles is not surprising. What is perhaps significant is that an important fraction came from other parts of India and abroad. The former is due to the connection with other universities and learned societies in India and the latter is due to contacts through research and because of research journals, and other periodicals.

Classification by month of the year is given in Table 5.

TABLE 5 ; MONTH OF THE YEAR

(January = 1, February = 2, etc.)

Month	1	2	3	4	5	6	7	8	9	10	11	12	Total
Total	60	70	91	88	65	52	50	26	65	63	37	36	703
Except 'examinations'	56	53	48	43	44	44	40	20	42	41	32	32	495
Invitations	10	18	4	14	14	7	6	5	8	10	5	13	114

The first five months of the year and September and October are the months when

the correspondence is relatively greater; and August is the lean month. The table also shows that the greater number of communications in March, April, May, September and October is largely due to those about examinations. It is also clear that invitations received during these months also contribute a substantial part to these greater numbers. Classification by weeks (four parts of the month) was also tried. It gave 171, 161, 221 and 160 for the four weeks. No comment is offered-the differences are not believed to have any relation to the structure of correspondence.

Table 6 gives the distribution of the 554 postal communications (excepting two telegrams) by the type of postal article[5]. It is natural that letters (221) was the biggest single item. The large number of book-posts is mainly due to invitations and notices about new publications. Many of the parcels were concerned with examinations. Foreign sea mail consisted of greeting cards, journals and magazines. There were 63 registered articles (letters, parcels and book-posts) about three-fourths of which were related to examinations. This explains the large amount of postage on these communications which was noted above. The postage on the registered articles (Rs. 116.63) naturally forms the major portion of the total postage.

TABLE 6 : TYPE OF POSTAL ARTICLES

	Total	Marathi
1. Post card	53	11
2. Inland letter	51	11
3. Letter	221	18
4. Parcel	44	—
5. Book-post	105	18
6. Magazine post	14	12
7. Foreign airletter	19	6
8. Foreign airmail letter	8	1
9. Foreign sea-mail	39	—
Total	554	77

The following table (Table 7) classifies the communications by the number of days taken to reach Mr. X from the date of despatch. All communications delivered by hand were delivered on the same day. The last category mainly con-

TABLE 7 : NUMBER OF DAYS FROM DESPATCH TO DELIVERY

On the same day	154
1 day	268
2 days	136
3 days	48
4 days	26
5 days	14
6 to 15 days	15
More than 15 days ...	42
Total	703

5 One railway parcel has been classified as a postal parcel for the sake of convenience.

sisted of foreign sea-mail communications. No remarks are offered except to mention the obvious dependence of these figures on the place of the sender given in Table 4.

In an attempt to find at whose initiative the communication was sent the following figures were obtained : (i) Reply to a previous communication of Mr. X 82, (ii) Continuation of correspondence 244, (iii) Sender's initiative 259, and (iv) Others 118. The last category includes magazines, journals, communications from conferences or bodies of which Mr. X is a member or those communications which could not be classified in the first three categories. Category (iii) included most invitations, except those few which came under (iv).[6]

REPLY COMMUNICATIONS

The return communications (or the correspondence *in reply* to the 703 communications received) will now be discussed briefly . It should be emphasized that this is *not* all its out-going correspondence of which this study makes no attempt to analyse. For this analysis the in-coming 703 communications are classified under two categories : (i) whether reply expected, (ii) whether reply sent.

TABLE 8 : CLASSIFICATION BY REPLY (EXPECTED AND SENT)

	Reply ordinarily expected	Marginal	Reply ordinarily not expected	
Reply sent	222	24	1	247
Reply not sent	18	24	414	456
Total	240	48	415	703

Replies were expected in the case of about one-third of the communications, and except in 18 cases they were sent. Of the 415 cases where reply was ordinarily not expected no return communication was sent except in one case. The marginal cases are those where it was difficult to decide either way; of 48 such cases replies were sent to half of them. For most of the communications by hand (121 out of 147) no reply was expected nor was it sent; when sent, it was sent invariably by hand. Of the 247 replies sent 30 were sent by hand; the remaining 217, sent by post, included 11 post cards, 51 inland letters, 130 letters, 5 parcels, 8 foreign air-letters, 10 foreign letters by air mail and two by foreign sea mail. There were 15 registered articles among them, and 10 of them were about examinations. The interval between the receipt of a communication and the date of reply (when it was sent) is given by the following figures.

TABLE 9 : NUMBER OF DAYS BETWEEN RECEIPT AND REPLY

On the same day	56
After 1 day	59
After 2 days	37
After 3 days	20
After 4 days	21
From 5 to 14 days	37
After 15 days	17
Total	247

6 It is evident that this classification was not very precise and therefore not very informative.

The total postage spent over the 217 reply communications sent by post was Rs. 58·69 out of which 110 communications pertaining to examinations accounted for Rs. 32·70, the remaining 147 making up for the remaining Rs. 25·99. If replies had been sent to 18 cases where it was ordinarily expected but not sent and to 24 marginal cases where it was not sent, an additional sum of Rs. 8.47 would have been spent on postage.

As mentioned above the reply communications do not cover the total outgoing communications and therefore it was not thought worthwhile to analyse them further for structure.

INVITATIONS

The category ' invitations ' which includes 114 communications will now be analysed in greater detail.[7] As mentioned above 73 of them were delivered by hand and 41 by post, the total postage for them being Rs. 3.34. They are classified by the social occasion (or function) as follows : (i) Wedding or thread ceremony 41, (ii) Meetings, lectures, conventions (mostly to listen to, a few to participate) etc. 33, (iii) Social gatherings of other colleges and institutions, and similar occasions 31, (iv) Other social occasions, 9. There were five invitations for dinner and three for tea. The classification by sender and comments thereon are already given above. (See : Table 3). The analysis by the address of the sender is given in Table 4. Eighty per cent of the invitations are local and this is quite natural. Classification by month of the year given in Table 5 shows that there are more invitations in November to February and again in April and May. The first period coincides with the period of social activities in collegiate institutions and both (especially the second) are the traditional wedding months of the Hindus.

Another interesting line of analysis was to classify the 114 invitations by (i) whether invited with wife or family and (ii) whether the function was attended. This is given in the following table.

TABLE 10 : INVITATIONS

	Attended				Not attended		Total
	Alone	With wife	With family	By wife	Not local	Local	
Invited alone	9	—	—	—	14	46	69
Invited with wife	4	1	—	1	1	14	21
Invited with family	1	1	1	3	6	12	24

It is evident that 69 invitations when Mr. X alone was invited must have been

[7] It should be mentioned that these are not *all* the invitations for social occasions which Mr. X received. They are the invitations in a written form and do not include those which were oral or by circular.

mostly for occasions or through contacts connected with his employment and profession. Even in the remaining 45 there were 10 which were due to his professional contacts. Mr. X did not attend 93 social functions to which he was invited; 21 of them were functions held outside Poona (and which therefore he was not ordinarily expected to attend). Thus Mr. X (or his wife) attended only 21 and did not attend as many as 72 of the 93 social occasions in Poona to which he was invited. If he had closer associations with Poona probably the total number of invitations as well as those to which he responded by his presence would have been greater. This activity will also naturally depend on the individual's temperament. (See the introductory paragraphs.)

It was found that Mr. X spent 35 hours over the 17 social occasions at which he was present, and spent Rs. 5.80 on transport for that purpose. (The expenses on presents etc. are not considered here.) Had he attended the 72 occasions (which he could have attended but which in fact he did not) he estimates that he would have had to spend 155 hours on them and about Rs. 20 on transport. The money requisites of this aspect of social life do not appear to be formidable but the time requirements do seem to be quite considerable.

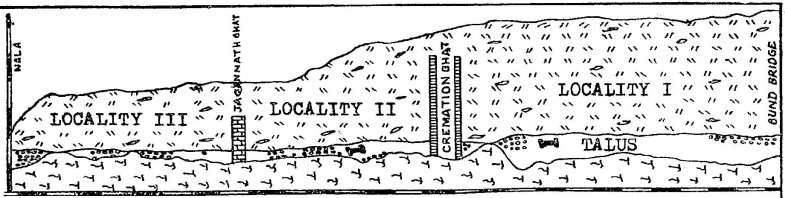
MARATHI COMMUNICATIONS

Finally we deal with the language of the communications received by Mr. X. This should throw light on an important aspect of the social life of an intellectual of his type. Only 131 out of 703 communications (19 per cent) were in Marathi, the remaining all being in English. There was no communication in any other Indian language including Hindi. Their further breakdown is given in Tables 3, 4, and 6. As many as 116 of these 131 were from the Marathi-speaking areas of the former Bombay State. Except four which were from the college office there were no communications in Marathi connected with the professional life of Mr. X. This is explained by the fact that the language of teaching and administration in colleges, universities and other institutions is English.

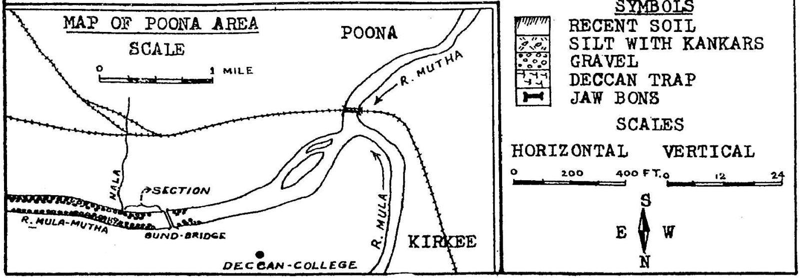
Classification of the Marathi communications by contents yielded the following figures : (i) Letters from relatives, friends and acquaintances (of a personal character) 40, (ii) Magazines, reports, etc. 18, (iii) Invitations 55, (iv) Others (which included 9 requests for votes, — it was the year of general election) 18. This confirms the conclusion arrived at above that there is hardly any Marathi communication regarding the present job or profession of Mr. X. Out of the 114 invitations only 55 were in Marathi, most of them being about wedding or thread ceremony. Classifying the Marathi coommunications by sender it is found that 43 of them were from relatives, friends, or acquaintances, 43 from colleagues or students (most of them being invitations) and 45 from other sources. Even if we confine ourselves to the relatives and friends of Mr. X only 27 out of the 71 communications received from them were in Marathi. This is in line with what Mr. X remarked to us, that a large majority of the letters that he writes to his relatives or to his (Marathi-speaking) friends are in English ! This lays bare an important aspect of the individual and social life of the present day Indian intellectual (of the class considered in this study). The analysis of the 77 Marathi

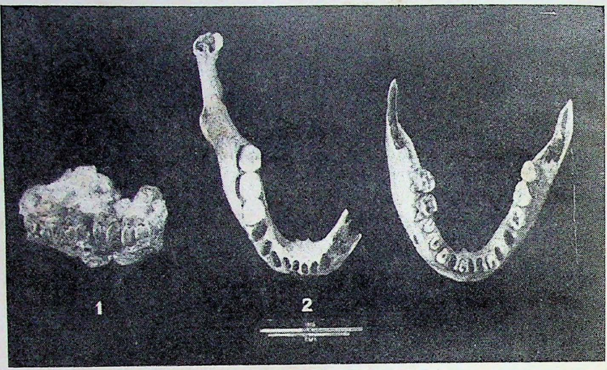
communications received by post by their postal category given in Table 6 and the fact that they accounted for a tiny fraction of the total postage—Rs. 10.42 out o a total postage of Rs. 226·75 for all in-coming communications — only confirms what has been observed above.[8]

[8] I should like to thank Professor I. P. Desai of the Baroda University for going through the first draft of the paper and suggesting improvements.



LONGITUDINAL PROFILE OF THE RIGHT BANK OF THE RIVER MULA-MUTHA NEAR THE BUND GARDEN POONA.





, Plate 1

Specimens From Localities I, II & III. Superior Aspect.

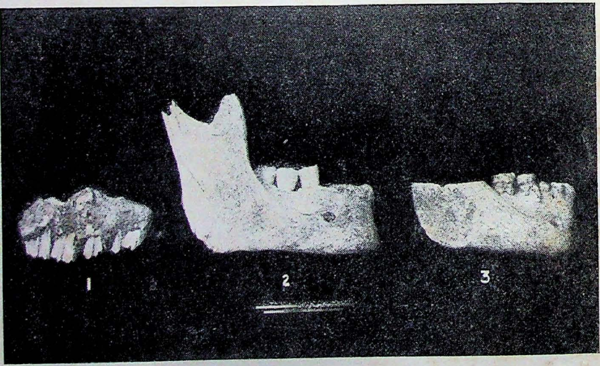


Plate 2

Specimens From Localities I, II & III. Right Lateral Aspect.

THE SKELETAL EVIDENCE FOR PLEISTOCENE MAN IN INDIA

by

RAJAGURU S. N.

KENNETH A. R. KENNEDY

The abundance of palaeolithic stone implements which have been found in direct association with Pleistocene geological and faunal deposits in India attests to the existence of man here some 150,000 years ago. However, the most ancient human skeletons so far available for scientific study can be dated no earlier than about 2500 B. C.[1] In the history of archaeological investigation in India there are several interesting cases of fossilized human bones having been discovered in apparent contiguity with Pleistocene deposits. In 1962-63 another such provocative find was made.

Dr. H. D. SANKALIA and Shri S. N. RAJAGURU of the Deccan College Post-graduate and Research Institute, Poona, found in a talus deposit on the right bank of the River Mula-Mutha near the Bund Garden (18 degrees 32 minutes North, 73 degrees 51 minutes East) three jaws (Fig. 1). Of these two were human, the other belonging to a sheep. The talus deposits abut eroding cliffs which rise almost vertically and which are of Pleistocene origin. The top of the cliff attains a height of about thirty-five feet above the water level of the Mula-Mutha in the dry season. This upper surface is flat and is the locus of a Hindu cemetery at the present day. The upper jaw of the sheep specimen was found at Locality I, a position one thousand feet downstream from the Bund Bridge. At Locality II, some eight hundred feet further downstream, a human mandible was uncovered. No record was kept for the exact location of another human mandible which was found in the close vicinity of the Locality II specimen, but it has been catalogued in the Department of Archaeology, Poona, as the Locality III human jaw. However the discoverers of these specimens did not entertain the idea that they are of Pleistocene age and contemporary with the talus from which they were taken. The specimens, especially the human jaws, were collected for the benefit of instructing students in anthropology and archaeology. Later their semifossilized condition was observed and hence their detailed description in the paper.

Of these three bone fragments, only that of the sheep is completely fossilized. It consists of a portion of the right half of a palate which holds two premolar and three molar teeth. The specimen has been identified as belonging to an *Ovis Vignei Blyth*, race *domesticus*, the common Indian domestic sheep[2] (Plates I & II, Fig. 1).

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1 This is a minimum date for the Late Stone Age industry at Langhnaj, Gujarat, where human burials have been found in association with microlithic artifacts and fosslized faunal remains. SANKALIA H. D. *Prehistory and Protohistory in India and Pakistan*, Bombay, p. 146, 1962.

2 Communication from the Zöological Survey of India, Calcutta, February, 1963.

The Locality II human mandible shows incipient mineralization and a mottled brown and white colour. The left corpus and ramus are missing, breakage occurring at a point immediately posterior to the distal wall of the alveolus of the left canine. The teeth preserved in the mandible are the three right molars, the rest of the dentition having been lost post-mortem. There is additional damage along the posterior border of the right ramus (Plates I & II, Fig. 2).

This Locality II mandible is of moderate size and within the range of variation for the present-day Maharashtrian population. The bilateral chin exhibits a moderate degree of anterior projection and the mental spine is well developed. The right mental foramen is large. The degree of gonial eversion is not high, but the attachment for the medial pterygoid suggests a pronounced muscular development of the specimen. Its lingual aspect reveals small, sharply defined genial tubercles and a robust mylo-hyoid crest which terminates at a lingula of small size.

Of the three teeth still preserved in the specimen the third molar is unworn, having erupted shortly before the time of death of the individual, while the first. and second molars are only slightly abraded. The latter two teeth each have four cusps defined by the+4 groove pattern. The third molar has five cusps. Radiating from the centre of this third molar is a ridge which terminates at the disto-lingual cusp and isolates a very small accessory cusp from the five larger cusps of the occlusal surface. This molar differs again from the other two teeth adjacent to it in the round conformation of its crown, the first and second molars having a rectangular shape of their crowns as these are viewed from above. The first molar is the smallest in the molar row: the teeth posterior to it are both larger in their disto-mesial and bucco-lingual diameters. Caries are not apparent in any of these three teeth. The alveoli of the teeth lost post-mortem do not indicate that crowding was a feature of the mandibular dentition.

The bilateral chin and the general robusticity of the mandible, and the recent eruption of the third molar suggests that the specimen from Locality II is that of a young adult male.

Fossilization of the mandible from Locality III has progressed further than in the specimen from Locality II. Its colour is grey with patches of brown. Both rami of this specimen are lost, and the fossae between the medial and lateral walls of the gonial portion of the mandible are exposed. The dentition lacks the two lateral and the left medial incisors, the left premolars, and the right third molar. The third molar was lost ante-mortem. Of the teeth remaining, the crowns of the incisor, canines, and right first premolar have been broken off: the crowns of the left first and second molars and the mesio-lingual aspect of the right second premolar are partially preserved (Plates I & II, Fig. 3).

This mandible is smaller than the one from Locality II. Its chin form is median and the anterior projection of the chin is moderate. The mental spine is very small. The gonia are slightly everted and the attachments for the medial pterygoids are weakly developed. The single genial tubercle is small but sharply defined in the median aspect of the lingual surface. Commensurate with the reduc-

tion of muscular features in this specimen are the small, rounded mylo-hyoid crests which end in small lingulae.

The left second and third molars bear the +4 groove pattern and four heavily abraded cusps. There is considerable variation in the shape of the occlusal surfaces of the crowns, the left third molar being round, the left second molar rectangular, and the right second molar representing the compressional type of crown surface. Post-mortem damage has affected the morphology of these teeth. The second molar is larger than the third molar, but trauma to the first molar precludes an accurate judgment of its place in the molar series. Dental pathology is not observed and crowding is also not apparent.

This is quite probably the mandible of an adult female. All of the mandibular teeth have erupted, and the corpus does not reveal an advancement of senile morphological changes.

The antiquity and relative contemporaneity of the three jaws cannot be ascertained from observation of differences in their degrees of fossilization Organic materials undergo the process of mineralization at rates which are largely controlled by the micro-environments of their deposits, hence different bone beds will affect widely varying results. Conceivably the sheep palate might post-date the human specimens inspite of its greater degree of mineralization. The identification of the fragment as belonging to the common breed of domestic sheep found in India today establishes a minimum palaeological date for the time of its existence. Similarly, the human specimens possess morphological features that can be found well within the range of variation for jaws of modern *Homo sapiens*. Nor is it possible to assume that the age of these jaws parallels the antiquity of the Pleistocene deposits from which they were taken. Artifacts and fossils from fluvial beds are subject to frequent redisposition, as evidenced by their 'rolled', or abraded, condition. The proximity of the cemetery on the high ground above the Mula-Mutha to the talus in which the three jaws were found is another argument for the exercise of great caution in any attempt to pronounce these human specimens as evidence for Pleistocene Man. Indeed, one of the authors, in company with Dr. PAUL E. SIMONDS of the University of Oregon, re-examined these same talus deposits in September, 1963, and observed large numbers of human and animal bones protruding from the drifts which had been eroded by recent rains. None of the human bones showed any signs of fossilization, and their affinity with the burial ground immediately above the talus was obvious.

The question of the ages of the Poona jaws and their relative contemporaneity can be answered when the specimens are subjected to chemical and radiometric assays. Modern methods of attacking the problems of the relative and absolute antiquity of fossilized human material have complemented traditional techniques dependent upon the observation of stratigraphy and the degree of mineralization apparent in a given specimen. In the light of these discoveries from Poona a review of other cases in the prehistoric records of India where fossil human bones have been claimed to be found in association with Pleistocene geological and faunal deposits is in order. The scrutiny of each of these fossils to modern dating techniques is recommended.

As early as 1846 the mineralized fragments of what were perhaps two hominids were uncovered at Umhut on the Koana River near Gorakhpur, Uttar Pradesh, in a pit filled with shells, deer horns, and miscellaneous mammal bones. The pit was from 12 to 15 feet in depth when the convict laborers struck this faunal assemblage. Mr. CARRE TUCKER, a bridge construction engineer who had ordered the deposit dug as a source of kunkur and lime, delivered a box of these shells, horns, and bones to the Asiatic Society of Bengal in Calcutta, where the collection was exhibited at the meeting of January, 1847[3]. In March of that same year, a letter from TUCKER to the Secretary reporting the circumstances of the discovery was published in the *Proceedings*.[4] The collection was subsequently lost in the Society's museum. Then in 1864, Mr. H. F. BLANFORD noted the existence in the museum's vaults of an unlabelled human skull consisting of an occipital bone, two parietals, and a portion of the frontal as well as upper and lower jaws which were filled with a mass of shells of the genus *Unio*.[5] It is to this latter specimen that Mr. W. THEOBALD refers in 1881 when reporting that the conglomerate from which it was taken resembled conglomerates which he had observed in Pleistocene beds of the Narbada Valley.[6] However, at the time of THEOBALD's report, the specimen was known to have been missing for many years. It was quite by accident that Mr. J. ANDERSON found a collection of unlabelled human bones in a remote recess of the Museum of the Asiatic Society of Bengal in 1883, and he was disposed to identify these with the specimens earlier described by BLANFORD and discovered by TUCKER.[7] Whether ANDERSON was justified in this decision or not is a question that can never be settled, and it is by no means obvious that the so-called ' Gorakhpur fossils' in the Indian Museum at Calcutta are the identical specimens discovered over a century ago by TUCKER. Nevertheless, bones bearing this lable were measured and described by MR. SISIRKUMAN HAR under the direction of Dr. PANCHANAN MITRA.[8] To this report, MITRA added the information that the bones of *Cervus* associated with the human material gave indications of having been worked into sharp instruments, such as have been found in Mousterian caves. The adventures of the ' Gorakhpur fossils ' might have ended with MITRA's comments but for the fact that DR. H. DE TERRA and Mr. T. T. PATTERSON made mention of THEOBALD'S description of a lost human cranium in the Museum of the Asiatic Society of Bengal in the account of their own discoveries of palaeolithic tools and Pleistocene bone beds in the conglomerates of the Narbada.[9] The statements of DE TERRA and

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3 TUCKER, H. C., Communication to the Secretary of the Asiatic Society of Bengal, *PASB*, March, *JABS* 16.1.376-77, 1847.

4 Ibid.

5 BLANFORD, H. F., *PASB*, Nov., *JASB* 33.5.575-76, 1864.

6 THEOBALD, W., The Siwalik Group of the Sub-Himalayan Region, *RGSI* 14.1.122, 1881

7 ANDERSON, J., *Korakhpur District Catalogue and Handbook of the Archaelogical Collection of the Indian Museum, Calcutta*, pp. 398–403, 1883.

8. MITRA, PANCHANAN, *Prehistroric India: Its Place in the World's Culture, Calcutta*, pp.385–88, 1923.

9 DE TERRA, H. and PATTERSON, T. T., *Studies on the Ice Age in India and Associated Human Cultures, Washington*, D.C., p.313. 1939.

PATTERSON were misinterpreted by Sir MORTIMER WHEELER to mean that THEOBALD had himself discovered a human fossil skull in a Pleistocene bone bed in Central India.[10] Thus there was introduced into the palaeoanthropological records of India a Narbada fossil hominid for which there is absolutely no evidence ! (Recent investigations by one of the authors (K. A. R. K.) at the Indian Museum, the Anthropological Survey of India, and the Asiatic Society of Bengal in Calcutta indicate that the 'Gorakhpur fossils' are again lost. We are grateful to Drs. P. C. Gupta, A. Basu and S. R. Das for their kind assistance with regard to our inquiries).

Another example of the finding of human bones in association with fossil mammal deposits is provided by MR. A. C. L. CARLLEYLE'S observation of five human skeletons at the Ahirpura Mound at Indor along the eastern bank of the Choya Nadi River[11]. While excavating here in the late ' seventies, CARLLEYLE found that fossil mammal bones and stone and bone artifacts were deposited beneath the foundation of an adjacent temple, but the association of the human bones and the tools with the historic temple rather than with the Pleistocene fauna cannot be excluded from consideration.

Mr. BRUCE FOOTE discovered a fragment of what Profs. GEORGE BUSK and BOYD DAWKINS identified as a human tibia in association with palaeolithic tools from the Attirampakkam nullah, a small affluent of the Corteliar which flows into the Bay of Bengal some eleven miles north of Madras.[12] However, FOOTE'S assertion that the human bone was contemporary with the palaeoliths remains unsubstantiated.

These four cases of the association of human bones with Pleistocene geological and faunal deposits in India make explicit the necessity for great caution in an interpretation of such finds. The intrusion of recent skeletal material into earlier deposits should always be considered. Only modern dating techniques can properly assess the claims of earlier investigators that the corporeal vestiges of Pleistocene Man have been found in India. For specimens which have been lost, their true natures can never be ascertained. The fossils from Gorakhpur, Ahirpura, Attirampakkan, and Poona hold a place in the history of prehistoric research in India that is paralleled in European palaeoanthropology by such early discoveries as were made at Cannstadt, Gailenreuth, Aveline' Hole, Kostritz, Bilzingsleven, Lahr, Paviland, Engis, Bize, Pondres, and Herhault. Few anthropologists are familiar with these site-names today, and for some of these localities the specimens are irrecoverably lost. Yet these dimly remembered fossils were the heralds of the later disoveries upon which much of current theory of human evolution is based. As prehistoric researches are broadened in India, and as more fully described fossil hominid remains are found, these early discoveries discussed above will find their proper place in the story of man's biological development in the Sub-continent.

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10 WHEELER, M., *Early India and Pakistan to Asoka*, London, p. 60, 1959.

11 CARLLEYLE, A.C.L., Report of Tours in the Central Doab and Gorakhpur in 1874-75 76, *ASI* 12,79-80, 1879.

12 FOOTE, B., *The Foote Collection of Indian Prehistoric and Protohistoric Antiquites, Catalague Raisonné*, Madras, 1914.

Table of Anthropometric Measurements of the Human Mandibles and Dentitions.

Mandibular Measurements :	Locality II	Locality III
Height of Symphysis	27 mm.	26 mm.
Bimental Diameter	32	31
Thickness of Corpus at Right First Molar	15	
Thickness of Corpus at Left First Molar		12.5
Thickness of Corpus at Right Second Molar.	18	13
Thickness of Corpus at Right Third Molar	18	14
Minimum Breadth of Ascending Right Ramus	34	
Maximum Breadth of Ascending Right Ramus	39.5	
Dental Measurements :		
Mesio-Distal Diameter		
Right First Molar	10	
Right Second Molar	11	6
Left Second Molar		10.5
Right Third Molar	11.10	10
Bucco Lingual Diameter		
Right First Molar	10.5	
Right Second Molar	10	9
Left Second Molar		9
Right Third Molar	10	
Left Third Molar		8
Crown Height		
Right First Molar	4	5
Left First Molar		4.5
Right Second Molar	5.5	6
Left Second Molar		7
Right Third Molar	6	
Left Third Molar		6.5
Crown Indices :		
Right First Molar	105,00	
Right Second Molar	90.90	150.00
Left Second Molar		100.00
Right Third Molar	90.90	
Left Third Molar		80.00

N.B. mm=Millimeters.

A CONTRIBUTION TO THE KNOWLEDGE OF INDIAN LATERITES*

by
A. D. KHARKWAL

INTRODUCTION

Since BUCHANAN's tour report " A journey from Madras through the countries of Mysore, Canara and Malabar " (1800-1801), attention of the petrographers has been drawn to what BUCHANAN described as " indurated clay ". This material was used by the Indians for the manufacture of bricks. Due to this particular use and according to the name given to it by the natives, BUCHANAN suggested the name " laterite " for the material (Latin : *later* = brick). According to him, " laterite " is a quartz bearing clay which contains red and yellow spotted iron compounds in large proportions. In natural moist conditions, bricks can be cut out of the laterite which harden on exposure to air and later become very resistant to weathering.

During the following decades of the 19th century, explorers reported on the widely distributed occurrences of laterites in the different parts of the tropics. For the first time, detailed petrographic examinations of these so-called laterites were made towards the turn of the last century. The field observations on the laterites as well as their mineralogical and chemical studies led, however, to contradictory views about their mineralogical composition, chemistry, occurrence, and origin. Since then no successful attempt has been made to define the term " laterite " more clearly and to put forward any satisfactory explanation for the genesis of the material. Most of the attempts made in this connection depended on the theories already in existence about the development of the tropical soils. The original definition of BUCHANAN was, however, hardly taken into consideration. In recent years, students of Indian and other lateritic occurrences have tried, in a purely descriptive way, to revert to the old definition of laterite by BUCHANAN. Thus PRESCOTT and PENDLETON mean by a laterite " a massive vesicular or concretionary ironstone formation ".

In the present paper, two Indian lateritic profiles have been studied for which material was collected by ZEUNER during a journey through India in the year 1949. The profiles are from Kot and Pedhamli in the north-west Indian state of Gujarat. Both the profiles show horizons which contain iron-oxide concretions. The material found between the concretions is of clayey nature. The geological conditions as described below suggest an *in situ* origin of the profiles. The require

* Translation of " *Beitrag zur Kenntnis indisher Laterite*" by *Heinrich Martin Koester*. Heidelberger Beitraege zur Mineralogie und Petrographie, Bd. 5, S. 23-64 (1955). Work carried out at the Sedimentpetrographisches Institut of the Goettingen University, West Germany.

ments of PRESCOTT and PENDLETON for a typical laterite-"a massive vesicular or concretionary ironstone formation "—are fulfilled in the case of both these profiles.

In this paper, the mineralogical conditions of the lateritic profiles have been clarified and the course of development of each profile has been traced. The numerous publications about laterite cannot be mentioned within the scope of this work. A review of the older literature is given by C. S. FOX . A large number of the most important works on laterite since the turn of the last century and the views expressed therein are cited by J. A. PRESCOTT and R. L. PENDLETON.

METHODS OF INVESTIGATION

Treatment of specimens and mechanical analysis

For the investigation of the laterite profiles, a method, which was never used before by any of the workers, was followed. Since the specimens consist predominantly of slightly hardened clay, it seemed useful to study them by special techniques of clay mineralogy. In order to facilitate a quantitative study by optical methods, X-ray analysis and differential thermal analysis (DTA), the specimens were subjected to mechanical analysis.

The specimens were treated, according to the normal method of Odén, by suspension in 0·01 n NH_4OH solution. The suspensions were shaken in a shaking machine for about 24 hours. The separation of the grains into the various size grades was carried out by sieving in the case of the coarse grains ($>0{\cdot}2$mmϕ) and by sedimentation in Atterberg cylinders in the case of the finer particles. Side by side with the Atterberg method, pipette analysis was also performed on a portion of each specimen to know the size distribution of the particles below 2 $\mu\,\phi$. These techniques are based on several years' experience of Correns and his co-workers.

The concretions of both the profiles could not be treated for mechanical analysis because of their very hard nature. Therefore, they were subjected to crushing into small fragments in a diamond mortar followed by further reduction to fine powder in an agate mortar, in order to make a quantitative study by means of X-rays and differential thermal analysis.

X-RAY METHODS

(a) *Debye-Scherrer method.*

X-ray diagrams of the concretions and of the total fractions $> 20\ \phi\,\mu$ of the treated specimens were obtained by using the Debye Scherrer camera (diameter 57·3 mm.). The material was packed in glass capillary tubes of 0·3 mm. diameter and was exposed each time to the CuK α radiation for 4 hours. Only in the case of iron bearing specimens, FeK α or CoK α radiation was used.

By means of a camera of 57·3 mm ϕ and a material of 0·3 mm in thickness, one can determine the position of the interference lines only with an accuracy of $\pm$ 0·2°. Densely packed interference lines are, in most cases, not clearly separated. As for example, the (001) reflections of montmorillonite and of chlorite with low glancing angles lie within the range of the primary flakes and are, therefore, not

recognisable. Such minerals can be hardly identified by this method. It proved, however, useful in distinguishing between the iron minerals as haematite and goethite. Semiquantitative determination of the minerals present was also carried out by comparing their diagrams with those of the standard minerals of known quantity. Thus the quartz content of less than 20% was determined by this method. For this purpose, standard mixtures of kaolin from Murfreesboro (which is a very pure kaolinite) and powder of quartz from Doerentrup were prepared with the quartz amounts 2,5,10 and 20 per cent respectively. The quartz content of the specimen under study was determined by comparing its diagram with that of the standard mixture. The most favourable lines for this purpose were the quartz reflections at d = 3·35 kX, 1·814 kX and 1·376 kX. In the case of a quartz amount of less than 10%, only the very strong 3·35 kX line was useful. Quantitative determination of the quartz content below 10% is possible by this method provided there is no mica in the specimen, otherwise the very strong (003) reflection of the mica mineral at d = 3·33 kX coincides with the 3·35 kX reflection of quartz.

An exact quantitative determination of the minerals was not undertaken because it is hardly possible to keep the working conditions uniformly constant for a large number of X-ray diagrams.

(b) *Orientation method* (Texturaufnahme).

For an X-ray study of platy minerals the oriented particle method of Jasmund is very suitable. The material is prepared by allowing the particles to settle by sedimentation on a flat surface. During sedimentation the platy clay minerals arrange themselves with their (001) faces parallel to the surface. A well oriented material yields only the (001) reflections of clay minerals with the camera described by Jasmund. This method offers the only possibility of identifying smal amounts of other minerals if present along with kaolinite. Especially the minerals of the montmorillonite group with a low glancing angle of (001) reflection can be identified with greater certainty. In the present work, the method proved very useful in recognising small amounts of mica and in distinguishing between the dioctahedral and trioctahedral micas on the basis of (001) and (002) interference lines. According to Nagelschmidt, the muscovite-like (dioctahedral) micas show equal intensities of (001) and (002) reflections while in the case of the phlogopite-biotite-like (trioctahedral) micas, the (002) reflection is either absent or very weak in intensity.

Quantitative determinations were not undertaken by this method because, apart from the usual difficulties of a quantitative X-ray analysis, a necessary prerequisite is a well oriented specimen which cannot be fulfilled even with greatest amount of care.

(c) *X-ray analysis with the Guinier Camera of v. Wolff.*

Lippman (2) has described the relative utility of the Guinier camera of v. Wolff. This camera is especially useful for understanding minor variations in the crystal structure within the individual groups of the clay minerals. In the present work, this camera was used in several cases for distinguishing between the

mica types and recognising differences in the structure of the minerals of the kaolin group.

According to MacEwan, the positions of (020) and (060) reflections are characteristics of the dioctahedral and trioctahedral mica. The glancing angle 2 θ for (060) reflection lies between d = 1·49 kX and 1·53 kX and between 1·53 kX and 1·55 kX for dioctahedral and trioctahedral mica respectively, while 2 θ for (020) reflection lies at d = 4·5 kX and at 4·6 kX respectively. Brindley has given data to distinguish between kaolinite and fireclay mineral by means of X-rays. According to him, in the case of well crystallised kaolinite, ($11\bar{1}$) and ($1\bar{1}\bar{1}$) lines are clearly visible, while in the case of the fireclay mineral, (020) and ($1\bar{1}0$) lines coalesce to form a diffuse reflection which turns into a broad band as the glancing angle increases and ($11\bar{1}$) and ($1\bar{1}\bar{1}$) reflections merge into this band.

Differential Thermal Analysis (DTA)

Quantitative determination of the clay minerals in fractions < 20 μ ϕ was carried out by means of differential thermal analysis. The apparatus for this purpose had been set up and further improved by Lippman (1). For a quantitative determination of minerals from the DTA curves, most of the workers have made use of curves of mixtures of standard minerals. All the values given for the minerals are in relation to the standard minerals. To what extent the values approach reality depends on the similarity existing between the standard mineral and the mineral under study. The standard minerals used in the present work were-kaolinite from Murfreesboro and from Schnaittenbach and quartz powder from Doerentrup.

Kaolinites in general give an endothermic reaction peak between 500 and 650° C which is due to the breakdown of the crystal structure as a result of dehydration and an endothermic reaction peak between 900 and 1000°C. Some kaolinites, like the halloysites and fireclay minerals, also show a weak endothermic peak at about 100°C. According to Lippman (1), one can distinguish between the fireclay mineral and kaolinite on the basis of the exothermic peak which lies between 900 and 950°C for the former and between 950 and 1000°C for the latter.

In natural conditions, minerals of sedimentary rocks are often concentrated in definite size grades. Mechanical analysis of such rocks sometimes yields nearly monomineralic grades. In the course of the present study, fraction < 2 μ ϕ of specimen number 108 was found to consist almost entirely of pure kaolinite. Debye-Scherrer diagram of the fraction also showed little quartz (<2%). Other interference lines than those of these two minerals were not seen at all. Hence it was concluded that the specimen contains at least 95% kaolinite.

In the case of standard mixtures of kaolin from Murfreesboro and from Schnaittenbach with the quartz powder from Doerentrup, there exists a linear relationship between the amount of kaolinite in the mixture and size of the endothermic peak at 580-585° C. Because of simplicity of measurement, the amplitude of the endothermic peak was used as a measure rather than the area of the peak curve. Linear relationship also exists between the size of the effect of quartz

inversion at 573 ° C and the amount of quartz in the specimen. The inversion effect of quartz was registered by reheating the burnt specimen. The results are given in fig. 1a. It is clear from this figure that in the quartz-kaolin mixture (which contains kaolin from Murfreesboro or Schnaittenbach) one can determine the kaolinite content with an accuracy of $\pm$ 5% (absolute error). Similar condition might hold good for mixtures of other kaolins with quartz. A straight curve was also obtained with the help of sp. no. 108 for mixtures of kaolinite of Kot with quartz. The kaolinite content of all the specimens of Kot and Pedhamli was determined from this curve (fig. 1a).

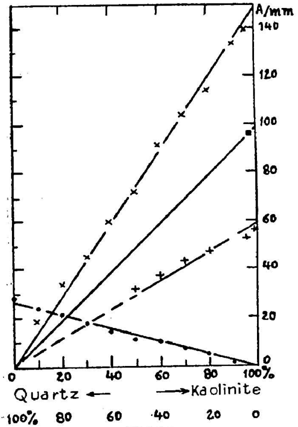

Fig. 1a

INDEX

Kaolinite from Murfreesboro ... ×
Kaolinite from Kot .... ■
Kaolinite from Schnaittenbach ... +
Quartz Powder from Dorentrup .... •

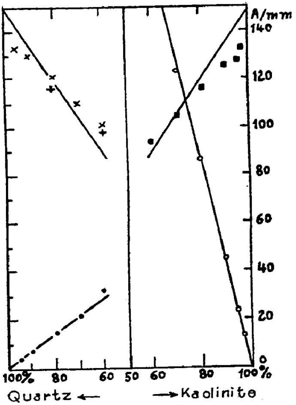

Fig. 1b

INDEX

Kaolinite + Goethite .... ×
Kaolinite + Haematite ...... +
Goethite .... •
Kaolinite + Calcite .... ■
Calcite .... o

Fig. 1a. Amplitudes of the endothermic reaction peaks of kaolinite (at about 550° C) and of quartz inversion in standard mixtures.

Fig. 1b. Amplitudes of the endothermic reaction peaks of kaolinite (at about 550°C), of goethite (at 350°C) and of Calcite (at about 800°C) in standard mixtures of kaolinite of Murfreesboro with goethite and calcite.

In the case of DTA., thermal conductivity of the specimen under study must be as far as possible equalised to that of the inert substance. The kaolinite of the lateritic profiles contained, besides quartz, goethite, haematite, calcite and mica in varying proportions. Of these four minerals, goethite, haematite and calcite influence the DTA curve of kaolinite in a different way than quartz. Due to their own thermal conductivity and great thickness of atomic packing, these minerals with high specific gravity change the thermal conductivity of the specimen considerably. By using calcined alumina as inert substance, mixtures of either of the standard kaolinites with goethite, haematite or calcite do not show any linear relationship between the kaolinite content and size of the endothermic peak at 580° C. Instead of straight lines they show slightly bent curves. In the case of the mixtures used for study, the kaolinite content varied from 60 to 95%. In this range one can determine the kaolinite content along with goethite, haematite and calcite with an accuracy of +10% (absolute error) with the help of a quartz-kaolinite curve. The endothermic reactions of goethite (at about 350° C) and of calcite (between 700 and 900°C) show a linear relationship between their size and the percentage amount of these minerals (fig. 1b). Using mixtures with the standard kaolin of Murfreesboro or Schnaittenbach, it is found that the standard curves of goethite and calcite practically do not change.

Hence the curves shown in fig. 1b were used for a quantitative determination of these minerals. For determination of the kaolinite content, the above mentioned standard mixtures with quartz were useful. The quartz content was determined quantitatively with the help of the curve of the mixture-kaolin from Murfreesboro and quartz powder from Doerentrup.

Quartz showed itself in the DTA curves even in amounts of ±5% with the apparatus used. Because of relatively small peak of the quartz inversion reaction, quantitative determination of small amounts of this mineral is very difficult. Therefore, it was felt necessary to check the determination of quartz by X-ray analysis. There is a good agreement between the values determined with DTA. and X-ray analysis.

Haematite and mica of the lateritic profiles did not show any reaction peak with DTA. In this respect the mica behaved like many biotites and muscovites which do not show any reaction even upto 1000°C. Therefore, the sum of haematite and mica was found out by subtracting the sum of the other minerals from the total (100%). The relative amount of haematite and mica was estimated from the X-ray diagrams. In this case it seems unsatisfactory that with the help of DTA haematite and mica can be determined only from a difference which is essentially dependent on the kaolinite content determinable with an accuracy of ± 10% Therefore, the results of the combined DTA and X-ray analysis were checked by applying the technique of the phase contrast microscope.

Microscopic Examination

The size grades above 20 μ ϕ were studied in grain slides with the help of a normal polarisation microscope. Normally slides with grains mounted in Canada

balsam served the purpose. It is only in special cases that liquids of different refractive indices were used for immersion of grains. Quantitative determination was made in each fraction by counting 300-400 grains.

By applying the phase contrast technique of Piller (1) the phase differences are converted into amplitude differences. The phase differences of light waves passing through different media are in this way made visible as intensity difference. Therefore, small particles, which are not visible in normal light on account of their weak absorption, can be recognised by means of the phase contrast microscope. The resolving power of the microscope is fully utilised by the phase contrast effect. This technique is well suited for observing grains of small size ($\pm$ 5 μ ϕ). By applying the " positive " phase contrast the particles which have a higher refractive index (R. I.) than the immersion medium appear darker and those R. I. having less than that of the immersion medium appear brighter. Those particles which have, in a certain wave-range, R.I. equal to that of the immersion medium, show a characteristic colouration in white light. The optical colouration of such grains depends on the difference between the dispersion of the particles and the immersion liquid. This effect was utilised in counting grains of the fractions 2-6 $\mu\phi$. and 6-20 $\mu\phi$ Using o-Nitrotoluol ($n=1\cdot544$) as the immersion medium, minerals with higher R. I. i.e., kaolinite and mica appeared dark and quartz grains were easily recognised by their bright blue colour. Calcite and haematite were identified and counted in the field of the normal light by putting out the phase contrast condenser. Distinction between kaolinite ($z = 1.560-1\cdot570$) and mica ($z = 1\cdot588$) was made by immersing the grains in o-Toluidin ($n= 1\cdot570$).

There is a good agreement between the results of the optical and DTA investigations of the fractions 2-20$\mu\phi$. Descripancies, however, appear only in the case of high contents of haematite and goethite.

The texture and mineralogical composition of the parent rock as well as the texture of the laterite specimens were studied in thin sections.

The results of X-ray analysis, DTA and optical study are discussed in detail in the following paragraphs.

I. LATERITE OF KOT

Description of the profile

In a publication " *Stone age and Pleistocene Chronology in Gujarat* " Prof. ZEUNER describes the occurrence of laterites in the neighbourhood of Kot. In the Sabarmati area, near about Kot, the basal rock is a granite which contains a high proportion of potash feldspar. The granite grades into a soft quartz bearing clay through a coarse sandy decomposed zone. The weathered material is partly removed away and on transportation sorted according to size. At places pure white clay is deposited in proximity to it. The primary quartz bearing clay as well as the reworked clay are quarried in the neighbourhood of Kot to serve as a raw material for the manufacture of porcelain. According to a chemical analysis carried out by SORAB DALAL China Works of Ransipur, the Si/Al ratio in the case

of practically quartz free specimen is 1·85/1. Hence this clay must contain aluminium hydroxide in addition to kaolinite. At Kot lateritic crusts of iron-oxide are encountered on this clay at certain places.

One of the laterite profiles is at a kaolin quarry north of the shaft of Kot. Here kaolinitised granite is also exposed.

The succession of specimens collected from the Kot profile from top to bottom is as follows :—

Specimen number (sp. no.)	104	Upper concretion horizon about 3·6 m thick (with iron-oxide concretions).
" "	103	Light coloured horizon (with iron-oxide concretions).
" "	102	Lower concretion horizon about 1.8 m thick (with iron-oxide concretions).
" "	101	Kaolinised granite about 3 m thick.

To supplement this section the following specimens have also been collected :—

Specimen number (sp. no.)	108	Kaolinitised granite of Kot.
" "	109	Alluvial kaolin of Kot.
" "	105	Granite of Eklara (coarse-grained variety).
" "	106	Granite of Eklara (fine-grained variety).
" "	107	Decomposed coarse-grained granite of Eklara (granitic sand).

Sp. no. 108 comes from the same kaolin quarry as the other specimens of the laterite profile. No account is available about the field relationship of this specimen with the laterite profile itself. The specimens no. 105-107 have been collected from Eklara which lies in the neighbourhood of Kot on the left bank of Sabarmati (Kot is situated on the right bank of the river). The granite is at places overlain by a Pre-Cambrian quartzite.

The profile of Kot seems to have originated from the decomposition of a coarse-grained granite whose composition might have been analogous to that of the Eklara granite (sp. no. 105). Therefore, the granite no. 105 was studied in detail, optically as well as chemically.

The granite of Eklara

The coarse-grained granite of Eklara consists of microcline, plagioclase quartz, biotite and hornblende as the essential minerals. The accessories, as seen under the microscope, are zircon, apatite and tourmaline which occur mostly as inclusions in the essential minerals.

The feldspars have the coarsest grains and form the predominant constituent. Their crystals are occasionally 1 cm or even more in diameter. In hand specimens, the feldspars form aggregates which are surrounded by fine-grained quartz. The

feldspars are essentially aggregates of microcline and plagioclase. The former is mostly perthitic. The typical corss-hatched structure of microcline is well developed in those grains which show a few albite lamellae. Inclusions of zircon, apatite and an unidentifiable mineral showing strong birefringence (probably sericite) are common in microcline. The plagioclases are twinned both on the albite and pericline laws. Their anorthite content ranges from 26 to 33% (determined by means of the universal stage and by simple optical methods). Needles of rutile and several fluid bubbles occur as inclusions in quartz crystals. Biotite and hornblende are intergrown with each other and occur mostly at the border of the feldspar aggregates. They contain inclusions of zircon, apatite, tourmaline and ilmenite.

Results of chemical analysis of the granite are given in table 1. The mineralogical composition as calculated from the analysis is as follows :—Potash-feldspar 31%, albite 25%, anorthite 9%, quartz 26% and biotite and hornblende 7%.

Table 1.

Chemical analysis of the granite of Eklara (*sp.* no.105)

	I %	II %	Mean value %
SiO_2	69.17	69.29	69.23
TiO_2	0.39	0.38	0.39
Al_2O_3	13.04	12.84	12.94
Fe_2O_3	2.14	2.11	2.13
FeO	1.34	1.39	1.37
CaO	1.66	1.70	1.68
MgO	1.36	1.39	1.38
MnO	0.05	0.05	0.05
H_2O+	0.97	0.95	0.96
H_2O-	0.55	0.54	0.55
Total	90.67	90.64	90.68

Alkali determinations

	a %	b %	c %
K_2O	5.97	5.41	5.48
Na_2O	2.93	2.62	2.55
Total	8.90	8.03	8.03

The alkali analysis a is of the same substance to which the main analysis belongs. But the analyses b and c are of other portions of the specimen.

It is very difficult to obtain, from the coarse-grained granite, an average sample corresponding to its natural chemical composition. The relatively large differences in the alkali determinations of the different samples reflect the microscopically recognisable concentratons of potash and lime-soda feldspars in the rock. The present analysis gives only a clue to the chemistry of the undecomposed granite.

The fine-grained granite of Eklara (sp. no. 106) differs markedly from the coarse-grained variety. The essential minerals of the fine-grained variety are microcline, quartz, biotite and hornblende. Plagioclase occurs in few isolated crystals Numerous tiny inclusions of apatite and zircon occur in the essential minerals. The feldspar and quartz crystals attain a size of 0·3 mm. ϕ. The essential minerals are, unlike the coarse-grained variety, uniformly distributed and do not occur in aggregates. Microcline shows the typical cross-hatching. Untwinned crystals of the potash feldspar are rare. The quartz crystals have few inclusions, particularly the fluid inclusions are extremely rare. Thus the fine-grained granite of Eklara differs considerably from the coarse-grained variety both in respect of texture and mineralogical composition.

Table 2.

Mineral constituents of the granite of Eklara (sp. no. 105)

	%	Molecular number	Bi	An	Ab	Or	Qu
SiO_2	69.23	1153	54	60	282	327	530
TiO_2	0.39	5					
Al_2O_3	12.94	255	18	60	94	82	
Fe_2O_3	2.13	27				27	
FeO	1.37	19	19				
CaO	1.68	30		30			
MgO	1.38	34	34				
MnO	0.05	1	1				
K_2O	5.97	127	18			109	
Na_2O	2.93	94			94		
H_2O+	0.96	107	36				

Biotite (Bi)	...	...	$K(Mg, Fe, Mn)_3(OH)_2AlSi_3O_{10}$	7%
Anorthite (An)	...	...	$CaAl_2Si_2O_8$	9%
Albite (Ab)	...	...	$NaAlSi_3O_8$	25%
Orthoclase (Or)	...	...	$KAlSi_3O_8$	31%
Quartz (Qu)	...	...	SiO_2	26%

Calculation of the mineral constitutents as " norm minerals " i.e., biotite, anorthite, albite, orthoclase and quartz is based on the model formulae given above. In order to simplify the calculation, hornblende present in the granite has not been taken into consideration. Even if it were considered, the values of the other minerals would not have changed materially because hornblende and biotite together form only 7% of the total mineralogical composition.

Laterite profile and its mineral constituents

As mentioned above, the granite of Kot is covered by its own weathering detritus-a quartz bearing clay. In the lower parts i.e., on the fresh surface of the granite, this clay contains a sandy material which is also a product of decomposition of the granite. Sp. no. 107 shows the composition of the sand.

The granitic sand consists of aggregates (about a cm. in ϕ) of microcline, quartz and biotite. Apparently these minerals are similar to those of the fresh granite (sp. no. 105). Microcline is perthitic and well twinned and contains inclusions of zircon, apatite and an unidentifiable substance showing strong birefringence. Quartz contains numerous fluid inclusions, apatite and needles of rutile. Hornblende and biotite are strongly decomposed. The latter appears yellowish.

There is no plagioclase in the granitic sand. Of the minerals of the granite, it is obviously most unstable against weathering. (N. B. Similar unstability of plagioclase has been pointed out by Piller (2) in the case of the recent weathering of the Broken granite. Under the climatic conditions of the Upper Harz, the product of weathering is not kaolin but one finds on the surface of the granite a sandy product consisting of potash feldspar, quartz and mica)

In the upper parts of the quartz bearing clay, the potash feldspar and hornblende are completely kaolinised and the micas are partly destroyed. Locally the white clay contains red concretions of iron-oxide in the upper parts. Sp. no. 101-104 represent this sequence.

According to PRESCOTT and PENDLETON, the essential feature of a lateritic section is the occurrence of iron-oxide concretions. In order to explain the origin of the laterite, one must be clear about the origin of the concretions. The course of development of the concretions can be recognised in their structure, mineralogical composition and from the changes produced by them in the underlying, overlying and surrounding materials. Since the concretions are embedded in a quartz bearing clay, the changes produced in the clay itself, both in respect of the size frequency distribution and mineralogical composition, were followed through the whole profile.

The size frequency distribution of all the four specimens shows two charecteristic maxima (fig. 2). The first maximum lies in the sand fraction; it shifts from the size grade 0·63-2 mm in sp. no. 101 to the grade 0·02-0·06 mm in sp. no. 104. The second maximum lies in the clay fraction below 2 μ ϕ. It is clear that from sp. no. 101 to 104, the proportion of the sand fraction decreases while that of the clay fraction increases.

Quartz.

Apart from sp. no. 104, the maximum at the sand fraction is due to quartz, which is prolific in fractions $> 0 \cdot 2$ mm ϕ of all the specimens. As mentioned above, there is a shifting of the position of this maximum from the grade 0·63-2 mm ϕ in sp. no. 101 to the grade 0·2-0·63 mm ϕ in sp. no. 104. In thin sections, one can recognise the reason for the diminution in grain size. In all the specimens, quartz is considerably corroded and in the cracks of its bigger grains calcite and kaolinite are found crystallised with the result that the cracks have been widened. From sp. no. 101 to 103, the fragments of quartz lie more and more away from one another. In sp. no. 104 no quartz fragments are seen. In the fine sand and silty fractions, the quartz content falls down abruptly and in the clay fraction it can be recognised only by means of X-rays.

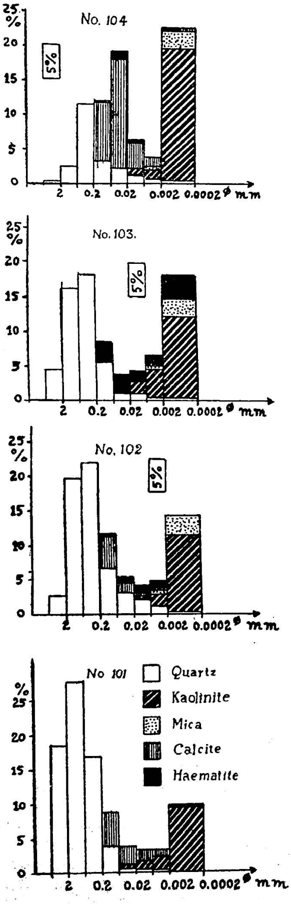

Fig. 2. Histograms of size frequency distribution and mineral distribution in the laterite profile of Kot.

The quartz content decreases from 68% in sp. no. 101 to 22% in sp.no. 104 (table 4). The relative error regarding these values would be about 10%. Aggregates of quartz are found only above 2 mm. ϕ. These appear to be mostly primary aggregates which are milky turbid in specimens no. 101 and 102 and glassy clear in the other two specimens. In the coarse sand fractions ($>0{\cdot}2$ mm ϕ), the character of the quartz grains can be studied by means of a binocular microscope. These fractions consist almost entirely of quartz but for a few isolated crystals of tourmaline. In the fractions 0·63-2 mm ϕ, quartz occurs mostly as separate crystals which are glassy clear. The aggregates, if at all present, are milky turbid and have often coating of iron-oxide (in specimens no 103. and 104).

The milky turbid grains often show cracks. Their turbidity seems to be partly due to corrosion and partly to kaolinite which has developed in the cracks. Their surface is often botryoidal. They show the greatest degree of corrosion in sp. no. 101 and the least in sp. no. 103. The glassy clear grains are angular, at the most slightly rounded at the edges. These are mostly fragments of quartz.

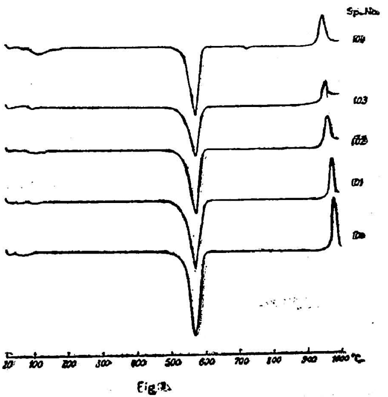

Fig. 3. DTA curves of fractions $<2\mu\phi$. Laterite profile of Kot.

Kaolinite.

In the specimens no. 101-104, against the decrease in the amount of quartz, there is a clear increase of the kaolinite content whose amount varies from 23 to 42%. The maximum of the size grade $> 2\mu$ ϕ which becomes more and more pronounced from sp. no. 101 to 104, may be due to an increase of kaolinite. This mineral also forms an essential component of the silty fraction.

In the fine sand fraction, it is present only in sp. no. 101 in the form of individual crystals and not as aggregates.

TABLE 3

Sp. no.	$<2\mu\phi$ °C	$<0.63\mu\phi$ °C
104	950	940
103	955	945
102	965	945
101	975	950
108	980	—

Quantitative determination of kaolinite was carried out by DTA. One can observe a change from kaolinite in sp. no. 101 to fireclay mineral in sp. no. 104. The transition from kaolinite to fireclay mineral takes place steadily. It is recognised by the shifting of the exothermic reaction peak of kaolinite from 975°C in sp. no. 101 to 950° C in sp. no. 104. A comparision of the corresponding Guinier diagrams shows a diffuse band becoming more and more pronounced behind (020) reflection. On the other hand, ($11\bar{1}$) and ($1\bar{1}0$) reflections become weaker and weaker so that they are no more present in sp. no. 104. (020) reflection shows an increase in intensity, while ($11\bar{1}$) reflection is not seen in any specimen.

DTA. curves of fractions $> 0{\cdot}63\ \mu\ \phi$ show, in contrast with the curves of the total fractions $>2\ \mu\ \phi$, a shifting of the exothermic reaction to lower temperatures (table 3). This can be explained by the fact that the smaller crystals of kaolinite

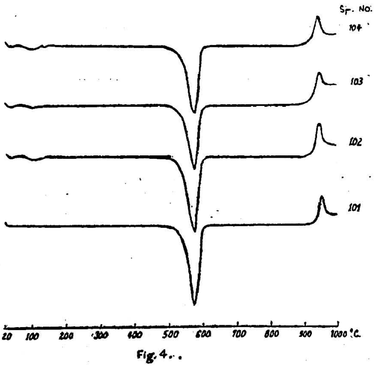

Fig. 4. DTA. curves of fractions $<0.63\mu\phi$. Laterite profile of Kot.

are poorly crystallised as compared to the larger ones. This is in aggrement with the observations of Lippmann (1) in the case of fireproof clays of Niederhessen.

On the basis of DTA curves and X-ray diagrams, kaolinite of sp.no. 101 can hardly be regarded as well crystallised. The missing order in the crystal structure increases in sp. no. 102 and still more in sp. no. 103. The limit between kaolinite and fireclay mineral might have been reached in sp. no. 104. DTA curve of sp. no. 104 shows a clear endothermic reaction of a kaolinic mineral between 100 and 150° c. The kaolin mineral of this specimen is to be regarded as fireclay.

Mica.

In the specimens of the lateritic profile, different kinds of mica occur together. Fractions 6·3-200 μ ϕ of all the specimens show, under the microscope, strongly leached biotite which is especially abundant in sp. no. 104. X-ray diagrams of the fractions > 2 μ ϕ and 2-6·3 μ ϕ of the specimens no. 102-104 show (001) and (002) reflections of dioctahedral mica. The reflections are sharp and lie at d = 10·0 kX and / or d = 5·0 kX. Besides, in the X-ray diagram of the fraction > 2 μ ϕ of sp. no. 103, one can recognise a diffuse reflection at d = 14·5 kX and a sharper reflection at d = 11.8 kX . The corresponding reflectons appear at d = 14 kX and d = 12·5 kX in the case of sp. no. 104.

X-ray diagram of sp. no. 101 did not show any mica. Similarly, no trace of mica was found in the X-ray diagram of the fractions 6·3-20 μ θ of the other specimens. However, isolated blades of mica can be recognised in the fractions above 6·3 μ ϕ. But their number is not sufficient for an X-ray study.

The interference lines at d = 10·0 kX and 5·0 kX can be ascribed to dioctahedral mica. The remaining lines of the specimens no. 103 and 104, which are very weak, may be due to hydrated mica and vermiculite.

Summary of the observations on mica.

In the fresh unaltered granite of Eklara only biotite is present. In the fractions > 6·3 μ ϕ of the lateritic profile, one finds only leached biotite. X-ray diagrams of the fine fractions show almost exclusively the basal reflections of a dioctahedral mica. The observed intensities of (001) and (002) reflections of this mica are equal. The basal reflections of the trioctahedral mica of the specimens no. 103 and 104 are much weaker than those of the dioctahedral one. The micas do not show any reaction to DTA.

A qualitative and quantitative comparision of the micas of the individual specimens of the profile shows that the micas are less decomposed in the upper parts of the profile than in the lower.

These observations signify the following :—

The basal reflections of the dioctahedral mica are due to sericite which occurs as inclusions in the potash feldspars. Sericite is identical with the microscopically unidentifiable but strongly birefringent inclusions in microcline of the granite. This mica, which is resistant to weathering, accumulates in the fine clay

fraction after the decomposition of the potash feldspars. Besides sericite, alteration products of biotite can be recognised by means of X-rays in the fine clay fraction of two specimens.

Table 4a. *Mineral constituents of the laterite profile of Kot*

Sp. No.	Fraction	Quartz	Kaolinite	Mica	(Haematite)	(Goethite)	Diaspore	Calcite	(Heavy minerals)	Total
104	<2	0.5	38.5	5.8				0.5		45.3
	2-6	0.5	1.5	0.2				1.6		3.8
	6-20	0.9	1.9	0.1	0.3			3.1		6.3
	20-63	2.3		0.2	0.9			15.6		19.0
	63-200	3.3			0.4			8.3	+	12.0
	200-632	11.5								11.5
	632-2000	2.4								2.4
	>2000	0.2								0.2
	Total :	21.6	41.9	6.3	1.6			29.1		100.5
103	<2	0.4	23.5	7.2	5.4					36.5
	2-6	0.2	4.2	0.4	1.7					6.5
	6-20	1.1	1.5		1.8					4.4
	20-63	1.1			2.6				0.1	3.8
	63-200	5.6			2.7				0.2	8.5
	200-632	18.4								18.4
	632-2000	16.4								16.4
	>2000	4.3								4.3
	Total :	47.5	29.2	7.6	14.2				0.3	98.8
102	<2	0.3	23.7	4.9			0.7			29.6
	2-6	0.9	1.8	0.5	1.5			0.1		4.8
	6-20	2.5	0.3		0.7			0.5		4.0
	20-63	2.1			1.3			1.8	0.1	5.3
	63-200	5.9			0.4			5.2	0.1	11.6
	200-632	22.0								22.0
	632-2000	19.7								19.7
	>2000	2.6								2.6
	Total :	56.0	25.8	5.4	3.9		0.7	7.6	0.2	99.6
101	<2	0.1	18.4					0.3		18.8
	2-6	0.1	1.9					1.1		3.1
	6-20	0.2	1.2					1.7		3.1
	20-63	0.4	0.5		0.1			2.7		3.7
	63-200	3.7						5.1	+	8.8
	200-632	16.8								16.8
	632-2000	27.8								27.8
	>2000	18.5								18.5
	Total :	67.6	22.0		0.1			10.9		100.6

Table 4b. *Mineral constituents of the laterite profile of Kot*

Sp. no.	Fraction	Quartz	Kaolinite	Mica	Haematite	Goethite	Diaspore	Calcite	Heavy minerals	Total
108	<2	0.5	50.3		1.5					52.3
	2-6	0.1	8.5		1.4					10.0
	6-20	0.1	3.8		1.2					5.1
	20-63	0.1	1.6		0.2					1.9
	63-200	0.6	2.4		0.2				0.1	3.3
	200-632	8.0	3.5							11.5
	632-2000	13.3								13.3
	>2000	2.6								2.6
	Total :	25.3	70.1		4.5				0.1	100.0
109	<2	0.4	33.7	3.4			0.9			38.4
	2-6	0.5	15.6	0.7	7.3			0.2		24.3
	6-20	0.7	8.9		2.7			1.3		13.6
	20-63	2.5	1.4		1.3			2.9		8.1
	63-200	5.8			1.0			0.3		7.1
	200-632	4.9								4.9
	632-2000	1.0								1.0
	<2000	2.1								2.1
	Total :	17.9	59.6	4.1	12.3		0.9	4.7		99.5

Iron-Oxide concretions

	Quartz %	Kaolinite %	Heamatite %	Goethite %
104	20	40	35	<5
103	50	30	20	
102	15	55	30	

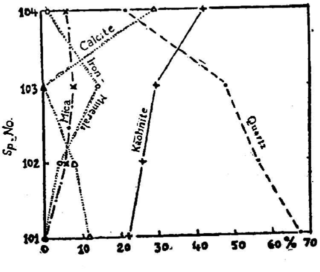

Fig. 5

Fig. 5, Distributiion of minerals in the profile of Kot.

Haematite.

Apart from the concretions, the only iron mineral that can be recognised in the profile of Kot is haematite. It is concentrated, in the form of scales, in the silty fraction and particularly in the fine sand fraction. Its proportion in the entire specimen is very small. Only in the fine fraction of sp. no. 103 its amount is 14%.

Calcite.

Calcite plays a significant role in the present profile. It occurs in considerable amounts in the specimens no. 101, 102 and 104, while it is absent from sp. no. 103. Thus its distribution is in sharp contrast with that of haematite which occurs in large amounts in the latter specimen.

The mode of occurrence of calcite can be understood from a study of the thin sections. It occurs crystallised between the grains of quartz and sometimes it is found penetrating into the cracks of the quartz grains. In the specimens no. 101 and 102, one finds quartz grains which are surrounded by calcite and whose cracks are still filled with kaolinite. This leads one to the conclusion that the quartz grains were at one time completely surrounded by kaolinite which must have been later replaced by calcite.

Table 4c. *DTA and optical analyses of clay fractions with the ph se contr st microscope (Phaco).*

Sp. no.	Fraction		Mica %	Kaolinite %	Quartz %	Calcite %	Haematite %
101	<2	DTA		90	<2	<2	
	2-6	DTA		60	2-5	35	
		Phaco		71	2	27	
	6-20	DTA		35	5-10	55	
		Phaco		38	5	57	
102	<2	DTA	(20)	80	2		
	2-6	DTA	(15)	35	20	<5	(25)
		Phaco	10	51	4	2	33
	6-20	DTA		10	65	15	(10)
		Phaco		5	63	12	20
103	<2	DTA	(20)	65	<2		(15)
	2-6	DTA	(10)	65	2-5		(25)
		Phaco	3	64	1		32
	6-20	DTA		35	25		(40)
		Phaco		19	23		58
104	<2	DTA	(10)	85	2	2	
	2-6	DTA	(10)	40	20	20	
		Phaco	5	45	7	43	
	6-20	DTA		30	15	55	
		Phaco	1	6	24	65	4

(Continued)— TABLE 4c.

Sp. no.	Fraction		Mica %	Kaolinite %	Quartz %	Calcite %	Haematite %
108	<2	DTA		95	<2		
	2-6	DTA		85	<2		(15)
		Phaco		87			13
	6-20	DTA		75	<2		(20)
		Phaco		77			23
109	<2	DTA	(10)	90	<2		
	2-6	DTA	(5)	60	~2	<2	(30)
		Phaco	2	69			<29
	6-20	DTA		60	~5	10	(25)
		Phaco		69	5	9	(16)

N.B. The values within brackets have been estimated from X-ray diagrams.

Diaspore.

Besides the above minerals, indication of diaspore was found in the X-ray diagram of the fraction $<2\ \mu\ \phi$ of sp. no. 102. Since diaspore crystallises with a tabular habit on the (010) face, only the orientation diagram showed the very strong (010) reflection at d = 3·98 kX. The remaining weaker interferences of this mineral did not appear at all. Its amount in the fine fraction is less than 5%, hence in the entire specimen it would be <1%.

According to the above mentioned analysis of Sorab Dalal China Works, Ransipur (Si/Al ratio of 1·85/1), one would expect a weight ratio of 26·51/1 for kaolinite/diaspore. In the case of sp. no. 102, this ratio is 35/1. These two values are on the whole in agreement.

Heavy minerals.

One finds in the profile only tourmaline and zircon as heavy minerals. Zircon predominates in frequency. Its crystals are colourless and well rounded. Tourmaline is idiomorphic and shows a strong pleochroism from yellow-brown to olive-green.

The heavy minerals and size frequency distribution indicate that the specimens no. 101-104 form a connected profile having an in situ origin.

Concretions in the profile of Kot.

Iron-oxide concretions in the specimens no. 102, 103 and 104 consists of a dense network of dark haematite-veins in whose interstices quartz and kaolinite are embedded. Kaolinite is more or less intermixed with haematite. The core of the concretions is made up of compact-looking haematite containing quartz grains uniformly distributed within its mass. In distribution and appearance (under the microscope), quartz grains are similar to those of the surrounding kaolin. This shows that the formation of concretions in the clay has taken place after the origin of the quartz bearing clay.

In the individual specimens, there exists a relationship between the amount of haematite in the concretions and that of the surrounding clay and the presence of calcite in the clay (compare table 4).

Besides haematite, a concretion of sp. no. 104 showed the presence of goethite.

Specimens no. 108 and 109

Sp. No. 108 comes from the same kaolin quarry as the above described lateritic profile. In respect of size frequency distribution, this specimen agrees with the specimens of the profile (fig. 7). The maximum of quartz lies, as in the case of sp. no. 101, between 0·6 and 2 mm ϕ. Quartz grains are glassy clear or turbid. Botryoidal form is absent . In thin section one notices a strong corrosion of the grains. The clay fractions are quantitatively larger than those of the specimens of the profile. The dominant clay mineral is kaolinite which seems, according to DTA and X-ray analysis, better crystallised than that of sp. no. 101. No indication of diaspore is found. Similarly, mica is altogether absent. Thus in this case kaolinisation is more perfect than in the laterite profile. The next important mineral in the clay fractions is haematite which is frequenctly intermixed with kaolinite. Tiny spherules of kaolin interspersed with iron-oxide occur upto the sand fraction. Kaolinite of the specimen did not go into suspension completely by the method applied for mechanical analysis. This might be due to strong binding of kaolinite with iron-oxide.

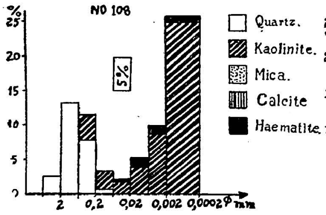

Fig. 6.

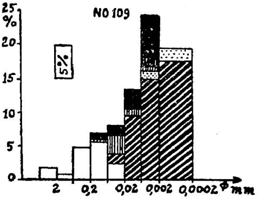

Fig. 7.

Fig. 6. Histogram of size frequency distribution and mineral disiribution in sp. no. 108.

Fig. 7. Histogram of size fcequency distribution and mineral distribution in sp. no. 109.

The alluvial kaolinite of Kot, sp. no. 109, is not fully in conformity with the kaolin of the other specimens so far as the size distribution is concerned. It is clear from fig. 7 that kaolinite is partly separated from the coarse sand fractions due to reworking. However, qualitatively the mineralogical composition is similar to that of the other specimens of Kot.

According to DTA and X-ray analysis, kaolinite of this specimen corresponds to that of sp. no. 108. The fine clay fractions contain dioctahedral mica. Calcite and haematite occur in considerable amounts in the fine sand and silty fractions. The dominant mineral of the sand fractions is quartz which occurs in botryoidal aggregates or as milky turbid grains.

Origin of the laterite profile of Kot.

The granite of Eklara and Kot has been subjected to kaolinisation. During this process, the feldspars and hornblende have been completely decomposed and the quartz grains considerably corroded; biotite has been leached and partially decomposed. The formation of concretions of iron-oxide in kaolin led to the development of a typical lateritic profile on the weathered granite.

Kaolinisation brought about a separation of the elements, iron and aluminium, which were present in the primary minerals of the granite. After separation, aluminium was almost completely bound with silica to form kaolinite while iron formed the oxidic minerals. Corroded grains of quartz and leached biotite were preserved as residual products.

The course of development of the laterite profile can be best traced in the residual products i.e., quartz and mica, on one hand and in the new minerals formed due to weathering i.e., kaolin and iron minerals on the other.

In the present profile, quartz grains are more corroded in the lower parts than in the upper. In contrast with this, cracking of the quartz grains increases progressively upwards. As for the micas, they are better preserved in the upper parts than in the lower.

In the lower parts of the profile kaolinite has gone into solution and in its place calcite has precipitated. On comparing the kaolin minerals, one discovers a transition of kaolinite to the fireclay mineral from the bottom to the top of the profile (fig. 3 & 4).

From the chemical analyses and mineralogical composition of the granite of Eklara one can approximately calculate the minerals expected after kaolinisation, provided (1) that quartz does not take part in the overall reactions, (2)

Table 5.

	%		Calculated to 100%
Quartz	26	SiO_2	42
	15.5	SiO_2 ...	
Kaolinite	13	Al_2O_3 ...	53
	4.5	H_2O ...	
Oxides	4	Fe_2O_3 etc.	5
	63		100

Table 6.

Sp. no.	Kaolinite/quartz
104	1.95/1
103	0.62/1
102	0.45/1
101	0.34/1

that feldspar, hornblende and mica are decomposed and all the aluminium is bound *in situ* in kaolinite, (3) that the released Fe, Ti, and Mn are present in the form

of Fe_2O_3, TiO_2 and MnO_2 respectively which remain preserved in the granitic material (table 5). The ratio kaolinite/quartz would amount to 1·25/1.

But in reality quartz is corroded and a part of it has gone into solution. The micas are not completely decomposed. A consideratoin of these facts is, however, not possible in a rough estimate like this. Mistakes caused by the calculation almost neutralise one another.

In the laterite profile, kaolinite of the specimens no. 101 and 102 has gone into solution and in its place calcite has precipitated. A comparision of the kaolinite/quartz ratio calculated for the kaolinised granite with the corresponding ratios of the individual specimens explains the role of kaolinite.

According to table 6, migration of the kaolinic substance must have taken place towards the upper parts of the profile. As a proof of this migration can be regarded the transition of kaolinite to fireclay mineral which follows a course from the base upwards. Occurrence of diaspore in sp. no. 102 indicates that free aluminium might have been present in the profile. Hence it can be concluded that migration of the kaolinic substance has taken place in solution and that the fireclay mineral is to be regarded as a product of recrystallisation of kaolin. Kaolinite could have dissolved only in alkaline solutions which might have at the same time corroded the quartz grains and decomposed the biotite.

Calcite can be considered as an indicator of pH of the solutions that were effective in the profile in the late stages. Solubility of calcium carbonate in watery solutions depends essentially on the concentration of free CO_2 in the solution. If the concentration of free CO_2 decreases, then naturally calcite must precipitate from a saturated solution of calcium carbonate. In nature, removal of CO_2 can take place by escape on warming up of the solution containing CO_2 or by neutralisation of H_2CO_3 by means of alkaline solutions.

In the profile of Kot, calcium carbonate bearing solutions seem to have migrated upwards from the base. In the specimens no. 101 and 102 calcite was obviously precipitated by the reaction of the ascending acidic solutions with the basic reagents of the lower parts of the profile. However, deposition of calcite in sp. no. 104 can be attributed to evaporation of solutions on the surface.

pH values determined on the specimens are given in table 7. An agreement of the determined values with the pH conditions that prevailed during the develop-

TABLE 7.

Sp. no,	Kaolin	Iron-oxide concretions
104	...	7·3
103	6·4	...
102	6·7	7·3
101	7·5	
108	6.6	

(For the pH-measurements suspension of 10 grams of the material of each specimen was prepared in 20 c. c. of distilled water.)

ment of the profile cannot be expected today[1]. But in spite of that the observed pH gradient of the profile explains as to why quartz of sp. no. 101 is more corroded than that of the other specimens and why much calcite has precipitated in sp. no. 101, less in sp. no. 102 and not at all in sp. no. 103.

The source of calcite lay most probably in the weathered plagioclases of the deepest weathering zone overlying the still fresh granite. It must have been carried into the profile by CO_2 bearing solutions. Its precipitation can be regarded as the last recognisable change in the lateritic profile.

From a study of the above described minerals, quartz, mica, kaolinite (and/or fireclay) and calcite, the following course of development of the profile can be visualised :—

The granite of Kot was kaolinised on the surface. Quartz and a part of biotite remained unaffected. In this case kaolinisation has taken place as a weathering process on the surface of the granite. It might have been brought about by the action of acidic solutions. One can well look upon H_2CO_3 as the principal agent of weathering as indicated by the presence of calcite.

After kaolinisation of the granite, basic solutions have strongly corroded the quartz grains and almost completely destroyed the mica in the lower parts of the profile. Kaolinite seems to have gone into the basic solutions which migrated towards the upper horizons where fireclay has been formed as a new mineral.

Then migration of calcite has taken place in the profile. The calcium carbonate has been transported by acidic solutions. On migration of these solutions in the basic reacting horizons calcite has precipitated.

During kaolinisation of the granite of Kot, oxidation of the iron present has taken place. Iron has migrated to the upper parts of the profile and has accumulated there in the form of oxidic minerals. Reduction of iron through an organic substance and its subsequent migration in a divalent form is extremely improbable and none of the observations gives any evidence of it. Iron must have, therefore, migrated as Fe^{+++} in acidic solutions. Its migration from the lower horizons and concentration in the upper has probably taken place before the appearance of basic solutions in the profile. Hence migration of iron has synchronised with kaolinisation of the granite or has taken place just after it.

The iron minerals have been at first uniformly distributed in the upper parts of the profile. The concretions are of later formation as is evident from occurrence in them of inclusions of kaolinite and quartz. Obviously there exists a relationship between the origin of concretions and occurrence of calcite in the profile. This is proved by a comparision of the specimens no. 102-104. In these specimens, which contain calcite, the concretions have a high percentage of haematite whereas

[1] In this conneetion it is interesting to note that in the course of exploratory diggings in Dutch Indies, van Bemmelen has measured similar pH values in a similar profile. In this case, the profile consists of a granite overlain by quartz bearing kaolin which grades into bauxite towards the top.

the surrounding clay shows a few scales of haematite in the fine sand and silty fractions. In sp. no. 103, which is devoid of calcite, the concretions contain relatively less haematite and especially the fine clay fraction of this specimen shows a higher proportion of haematite.

(In this connection, it might be mentioned that sp. no. 103, like the specimens no. 102 and 104, consists of iron-oxide concretions and white clay. Since the clay does not contain any calcite, it is not brittle and crumbly as the clays of the specimens no. 101, 102 and 104 are. The red concretions are surrounded by this clay and are therefore hardly recognisable. For this reason, the horizon of sp. no. 103 appears in the field as a " light coloured horizon ").

Regarding the process of the formation of concretions, nothing can be said with certainty on the basis of the observations. However, under the conditions mentioned above, its formation probably synchronised with the precipitation of calcite.

Although sp. no. 108 is from the same kaolin quarry as the laterite profile, but in mineralogical composition it differs from the other specimens. Absence of mica and strong corrosion of quartz (as seen in sp. no. 101) give proof of an advanced stage of kaolinisation. A secondary effect of basic solutions as observed in the laterite profile has not taken place in this case. The specimen is completely devoid of calcite. Kaolinite is not at all displaced and it is better crystallised than the kaolinite of sp. no. 101.

The ratio kaolinite/quartz of sp.no. 108 is 2·75/1. Hence it contains much more kaolinite than the amount expected from the analysis of the granite of Eklara. The reason for this could be found in the strong corrosion of quartz grains. In that case more than half of the original quartz of the granite would be required to undergo weathering. But microscopic study reveals that so much quartz has not gone into solution. Another possibility would be that sp. no. 108 comes from a feldspar-rich pegmatite vein of the granite, although the specimen itself does not give any indication of this. Yet another possibility is of an addition of kaolinite which would account for a high ratio of kaolinite/quartz.

Kaolinite of sp. no. 108 is well crystallised. In the case of a possible addition and recrystallisation of kaolinite, quite different conditions must have prevailed from those which led to the formation of the fireclay mineral in sp. no. 104. For the formation of the fireclay mineral ascending solutions were responsible, which underwent evaporation on the surface. Thus the fireclay mineral was deposited from oversaturated solutions.

For a clarification of the exact position of sp.no. 108, a systematic study of more specimens of kaolinite from Kot would be useful.

The course of development of the profile of Kot can be summarised as follows :—

The granite of Kot was kaolinised due to weathering on the surface. In the course of kaolinisation, plagioclase, potash feldspar and hornblende were completely decomposed. Biotite was partly preserved and leached. Quartz was corroded.

During or after kaolinisation, iron migrated upwards in the profile and oxidic minerals of iron were concentrated in the uppper horizons. These minerals were at first uniformly distributed in kaolin.

After the migration of iron compounds, in the lower parts of the profile quartz was strongly corroded by basic solutions, mica was almost completely destroyed and a part of kaolinite went into solution. The kaolinite in solution migrated towards the top where a new mineral fireclay was formed.

Migration of the kaolinic substance was followed by ascent of acidic solutions from the base. From these solutions calcite precipitated in the lower parts as well as on the surface of the profile.

The formation of the iron concretions is a process which could not be made out in the profile of Kot. It has definitely taken place after kaolinisation of the granite as is evident from the occurrence of quartz and kaolinite as inclusions in the concretions. Relationships between the distribution of iron minerals and of calcite suggest that probably the formation of concretions and precipitation of calcite have taken place at about the same time.

II. The Laterite of Pedhamli

Description of the profile

According to the account of Zeuner, there is another important occurrence of laterite near Pedhamli in the Sabarmati area. At this place the laterite has developed on red and white-banded Cretaceous sandstone. The thickness of the laterite is 3·5-5 m. It is overlain by a calcareous fluviatile sand and hence it is not recent. On the surface of the granite one finds concretions of calcite.

The geological conditions of the area reveal that the Cretaceous sandstone with its lateritic cover formed a low hillock which was subsequently buried under the fluviatile sands of Sabarmati.

The following specimens have been collected from this laterite profile :— (Date of collection 18-1-1949).

Sp. No.

119 Red and yellow coloured, hard superficial crust of the profile (4·80 m. above sp. no. 110).

118 Light coloured sandy soil with yellow and orange-red spots (4·50 m. above sp. no. 110).

117 Red, yellow and violet-spotted soil, more compact than sp. no. 116 (3·90 m. above sp. no. 110).

116 Red, yellow and violet spotted soil (3·60 m. above sp. no. 110).

115 Scoriaceous iron-oxide concretions (2·70 m. above sp. no. 110)

114 Scoriaceous iron-oxide concretions (2·10 m. above sp. no. 110)

113 Yellowish white soft sandstone from a cleft in the same horizon as sp.no. 112 (1·20 m above sp. no. 110).

112	Red sandstone traversed by white veins (1·20 m above sp. no. 110).
111	Red banded sandstone.
110	Cretaceous sandstone of Pedhamli *in situ* at the base of the laterite profile.
120	Cretaceous sandstone of Pedhamli.

The Cretaceous Sandstone

The Cretaceous sandstones of Pedhamli, specimens no. 110 and 120 are white, fine-grained and soft sandstones consisting predominantly of quartz, muscovite and kaolinite. Haematite also occurs in small amounts. The heavy minerals, tourmaline and zircon, are quite frequent.

The difference between the two sandstones lies essentially in the size frequency distribution (fig. 8 and 9). Both the specimens show a strongly pronounced maximum in the fine sand fraction. In the case of sp. no. 120, the maximum lies in the fraction 20-63$\mu\phi$ while in the case of sp.no. 110, it lies in the fraction 63-200$\mu\phi$. This maximum is largely due to quartz.

Quartz.

The principal constituent of the sandstones is quartz. It forms about 50% of the very fine-grained sandstone (sp. no. 120). In sp. no. 110 its amount is about 62·5%. Under the microscope, the grains do not show any sign of corrosion. The grains above 0·2mmϕ in sp. no. 110 and those above 0·06 mmϕ in sp. no. 120 are essentially quartz aggregates cemented together, the cementing material being kaolinite.

Muscovite.

Each of the two specimens contains about 26% muscovite. The optical and X-ray data that could be determined are given in table 8.

Table 8

d (100) = 10.48 kX	n_z = 1.588
d (200) = 5.06 kX	2V = 40°
d (060) = 1.510 kX	

(The optical data have been determined on crystals of the fractions 20-63 $\mu\phi$ in sp. no. 110. The X-ray values are from the orientation and Guinier diagrams.)

It forms the main constituent of the clay fractions of both the specimens. Its amount is also relatively high in the fine sand fraction of sp. no. 110.

Muscovite plays an important role in the weathering of the sandstones. Under the phase contrast microscope, one can recognise the alteration of muscovite into kaolinite. On immersing the grains in o-Toluidin (n = 1·570), one notices several crystals of muscovite altering, along their borders, into a substance of lower R. I. Some of the crystals also show thin translucent scales of lower R. I. branching out from the surface. Because of their optical colouration, these products of alteration have apparently R. I. almost equal to that of the immersion medium. X-ray analysis has proved that the alteration product is kaolinite.

Kaolinite.

Kaolinite occurs in fractions ranging from fine clay to fine sand of both the specimens. Its amount is about 19% and 9% in sp. no. 120 and sp. no. 110 respectively. The crystals occurring in the fine sand fraction are thin, elongated and large. They are alteration products of muscovite as mentioned above. R.I. (n_z) lies between 1·563 and 1·567.

Diaspore.

Presence of a small amount of diaspore was recognised in sp. no. 110 by the orientation method of X-ray analysis.

Heavy minerals.

The heavy minerals of the sandstones, in order of abundance, are tourmaline, zircon, rutile and biotite. Their proportion in the sandstones is about 1-2%. Tourmaline and zircon very well resemble those of the granite of Eklara and Kot. Haematite is of little importance in the sandstones.

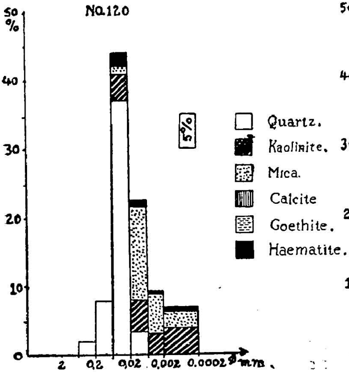

Fig. 8.

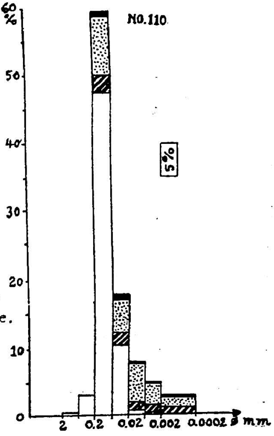

Fig. 9.

Fig. 8. Histogram of size frequency distribution and mineral distribution in the Cretaceous sandstone, sp. no. 120.

Fig. 9. Histogram of size frequency distribution and mineral distribution in the Cretaceous sandstone, sp. no. 110 which underlies the laterite profile of Pedhamli.

The texture of the sandstones can be studied in thin sections. Sp. no. 120 clearly shows fine lamination which may be due to a sudden change in the grain size composition of the individual layers. Sp. no. 110 does not show any lamination.

The white sandstones are interbedded with bands of red sandstone (sp. no. 111), whose main constituent is haematite. This sandstone is finely laminated and the individual layers differ in the amount of haematite. It is especially abundant in the dark layers which are only a mm in thickness. Since the red sandstone is very compact, it could not be treated for mechanical analysis. DTA carried out on the powder of the specimen showed the following composition :—Quartz 60%, kaolinite 10%, muscovite and haematite 30%. From the X-ray diagrams the amount of haematite can be estimated at about 20% (table 9).

The laterite profile.

The formation of laterite is due to weathering of the above described Cretaceous sandstone. During this process muscovite partly altered to kaolinite and quartz was corroded. Haematite was removed in solution from the red bands of the sandstone. The weathering process can be easily recognised in the following specimens :—

Sp. no. 112. It is a red sandstone traversed by white and whitish yellow veins which divide the rock into distinct nodules showing lamination and banding as seen in sp. no. 111. The original haematite has been dissolved away from the white veins lying between the nodules. In this way the original texture of the sandstone is destroyed. Small amount of calcite is also deposited in the veins. The mineralogical composition of the white veins and of the nodules is given in table 9b.

Sp. no. 113. It consists of a material similar to that of the white veins of sp. no. 112. The specimen was collected from a cleft of the same horizon as sp.no. 112. It is a soft yellowish white sandstone. Its size frequency distribution and mineral constituents are shown in table 9a and fig. 10.

TABLE 9a, MINERAL CONSTITUTENTS OF THE PROFILE OF PEDHAMLI.

Sp. No.	Fraction	Quartz	Kaolinite	Mica	Haematite	Goethite	Diaspore	Calcite	Heavy minerals	Total
119	<2	0.8	13.7	7.4	5.5					27.4
	2–6	0.6	1.2	1.8	2.5			0.1		6.2
	6–20	1.5	0.8	1.5	2.2			1.5		7.5
	20–63	2.5		0.1	1.4			3.1	0.2	7.3
	63–200	9.4			0.5			5.5		15.4
	200–632	8.5			0.6			3.5		12.6
	632–2000	2.4						20.0		22.4
	Total :	25.7	15.7	10.8	12.7			33.7	0.2	98.8

(Continued)— TABLE 9a.

Sp. no.	Fraction	Quartz	Kaolinite	Mica	Haematite	Goethite	Diaspore	Calcite	Heavy minerals	Total
118	<2	1.6	44.8	8.9	3.0		1.5			59.8
	2–6	1.6	2.0	0.8	3.6					8.0
	6–20	3.3	1.2	0.4	3.3					8.2
	20–63	3.1		0.1	1.8			0.1	0.1	5.2
	63–200	10.6			0.5			0.1	0.1	11.3
	200–632	4.2			0.4				0.1	4.7
	632–2000	2.1								2.1
	Total :	26.5	48.0	10.2	12.6		1.5	0.2	0.3	99.3
117	<2	1.0	21.4	3.9	3.9	8.8				39.0
	2–6	0.5	1.4	1.4	2.1	1.5				6.9
	6–20	1.0	1.0	1.0	3.0	3.9				9.9
	20–63	1.1			5.2			0.3		6.6
	63–200	3.0			12.0			0.2		15.2
	200–632	3.3			13.1					16.4
	632–2000	1.0			5.4					6.4
	Total :	10.9	23.8	6.3	59.9			0.5		100.4
116	<2	0.4	52.6	3.0	3.0	3.2	1.6			63.8
	2–6	0.7	1.4	0.3	4.0	0.5				6.9
	6–20	1.6	1.6	0.2	3.6	1.0				8.0
	20–63	1.3		0.1	3.3				0.1	4.8
	63–200	2.1		0.05	1.9			0.05	0.1	4.1
	200–632	2.2			2.1					4.3
	632–2000	1.3			5.0					6.3
	>2000				1.3					1.3
	Total :	9.6	55.6	3.65	28.9		1.6	0.05	0.2	99.5
113	<2	0.3	17.1	12.3	0.7		0.7			31.1
	2–6	0.3	1.7	5.7	0.7					8.4
	6–20	0.3	0.9	4.1	0.8					6.1
	20–63	5.1	0.1	1.0	0.8				0.4	7.4
	63–200	19.0			1.0				0.6	20.6
	200–632	16.8							0.2	17.0
	632–2000	8.7								8.7
	Total :	50.5	19.8	23.1	4.0		0.7		1.2	99.3

Sp. no. 113 differs from sp. no. 110 in the following way :—The percentage of the coarse sand fractions (<0·2 mm ϕ) in sp. no. 113 is much more than in sp. no. 110 (compare fig. 9). The quartz grains are corroded and the amount of kaolinite is twice as much as in sp. no. 110. Similarly diaspore content is also higher. The maximum of muscovite lies in the fine clay fraction and not in the coarse fraction as in sp. no. 110 or sp. no. 120.

The parent rock of sp. no. 113 must have been a sandstone coarser than sp. no. 110. The maximum of mica in the fine clay fraction, a high content of kaoli-

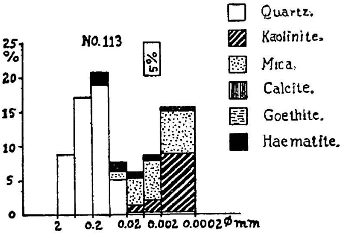

Fig. 10.

Fig. 10. Histogram of size frequency distribution and mineral distribution in sp. no. 113.

nite and corrosion of quartz grains indicate that the rock is considerably weathered. Judging from its position in the profile and degree of weathering, it seems to have originated from a red sandstone by leaching out of haematite.

Sp. no. 114 *and* 115. These are scoriaceous iron-oxide concretions consisting of quartz, kaolinite, mica, calcite, haematite and goethite (table 9b). White and red portions can be distinguished on the concretions. The red portions consist of haematite, kaolinite, muscovite and quartz while the white ones are made up largely of kaolinite, muscovite and little calcite.

Quartz grains of the concretions are considerably corroded and occur distributed in a thick groundmass of haematite. In the cracks of the quartz grains crystallised haematite is found.

Table 9b. *Mineral constituents of the profile of Pedhamli*

Sp. no.	Fraction	Quartz	Kaolinite	Mica	Haematite	Goethite	Diaspore	Calcite	Heavy minerals	Total
110	<2	0.1	2.5	3.0	0.4		0.2			6.2
	2–6	0.3	1.0	3.3	0.3					4.9
	6–20	0.7	1.3	5.6	0.4					8.0
	20–63	10.7	1.8	4.7	0.4				0.5	18.1
	63–200	47.4	2.4	8.9					0.6	59.3
	200–632	3.2								3.2
	>632	0.1								0.1
	Total :	62.5	9.0	25.5	1.5		0.2		1.1	99.8

Table 9b. *Mineral Constitutents of the profile of Pedhamli.*

Sp. nn.	Fraction	Quartz	Kaolinite	Mica	Haematine	Goethite	Diaspore	Calcite	Heavy minerals	Total
120	<2	0.3	7.4	4.8	1.0					13.5
	2–6	0.2	2.8	5.7	0.5					9.2
	6–20	3.4	4.5	13.8	0.9					22.6
	20–63	36.1	4.4	1.3	0.9				1.3	44.0
	63–200	7.6		0.1	0.1					7.8
	200–632	2.1								2.1
	Total :	49.7	19.1	25.7	3.4				1.3	99.2

Iron-oxide concretions

Sp. no.		Quartz %	Kaolinite %	Mica %	Haematite %	Goethite %	Calcite %
119	superficial crust	20	25	10	30	5–10	5
117	Red portion	10	25	10	20	30–40	5
117	Yellow portion	10	25	10		5–10	50
115	Red portion	15	35	10	35	5–10	
115	Light portion	20	40	25			15
114	Red concretion	2–5	35	15	40	5–10	
112	Red nodule	25	10	15	35	5–10	
112	White veins	40	10	20			30
111	Red sandstone	55	10	10	25		

Relicts of sandstone texture, as seen in sp. no. 112, are not to be recognised in the specimens no. 114 and 115. The high content of iron minerals may be partly due to their enrichment after the leaching out of quartz. A considerable amount of iron might have migrated from the deeper horizons. At least recrystallisation of iron compounds has taken place *in situ* as is evident from the fact that haematite and goethite are found crystallised in the cracks of the strongly corroded quartz grains.

Sp. no. 116. It is a loose material. Mechanical analysis shows that it contains > 60% of fine clay fractions. The whole specimen contains 50% kaolinite. Haematite, goethite and diaspore form about 30%. The amount of quartz and muscovite is very low. Tourmaline and zircon are the only heavy minerals present. The quartz grains are partly coated with iron-oxide and show corrosion.

The size frequency distribution of muscovite and the maximum in the fine clay fraction are indicative of strong weathering of mica. The high kaolin content has not only resulted from the weathering of the original muscovite but a part of it has been added to the specimen as will be shown below.

Haematite and goethite occur not only in the clay fractions but also in the sand fractions in the form of pisoliths whose size ranges upto 3 mm ϕ. Diaspore is present only in the fine clay fraction.

The heavy mineral content and the size frequency distribution of quartz with a maximum at 0·2 mm ϕ show that the original sandstone of sp.no. 116 had a composition analogous to that of sp. no. 113.

Sp. no. 117. It is similar to sp. no. 116 in respect of mineralogical composition and size frequency distribution. Mechanical analysis shows a lower proportion of fine clay fractions than in sp. no. 116 (table 9a). Correspondingly the kaolinite content is also much lower.

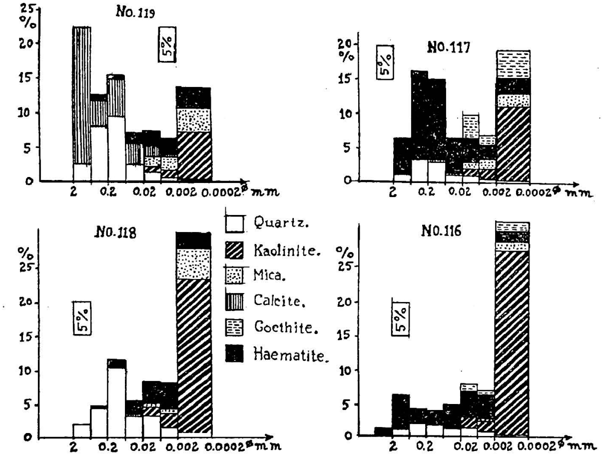

Fig. 11.

Fig. 11. Histograms of size frequency distribution and mineral distribution in the specimens no. 116–119.

The size frequency distribution of quartz is similar to that of sp. no. 116. The amount of quartz and muscovite is low. Under the microscope, quartz grains clearly show corrosion. The mica, due to its concentration in the fine clay fraction, is strongly weathered. About 60% of the specimen is composed of haematite and goethite. They are the principal constituents of the sand fractions in which they occur in the form of pisoliths. Goethite is also abundant in the fine clay fraction.

The high proportion of iron minerals is responsible for the higher degree of compactnes of sp. no. 117.

Table 9c. *DTA and optical analysis of clay fractions with the phase contrast microscope (Phaco)*

Sp. no.	Fraction		Mica %	Kaolinite %	Quartz %	Calcite %	Haematite etc. %
120	<2	DTA	(35)	55	2–5		(15)
	2–6	DTA	(70)	30	5		
		Phaco	16	78	1		5
	6–20	DTA	(65)	20	15		
		Phaco	29	52	15		4
110	<2	DTA	(50)	40	<2		(10)
	2–6	DTA	(80)	20	<5		
		Phaco	32	53	8		7
	6–20	DTA	(80)	15	<10		
		Phaco	67	19	9		5
113	<2	DTA	(40)	55	2		(5)
	2–6	DTA	(80)	20	5		
		Phaco	45	45	2		8
	6–20	DTA	(80)	15	5		
		Phaco	66	17	3		14
116	<2	DTA	(5)	85	+		(10)
	2–6	DTA	(5)	20	20		(55)
		Phaco	15		2		83
	6–20	DTA		20	20		(60)
		Phaco	4	2	5		89
117	<2	DTA	(10)	55	2–5		(35)
	2–6	DTA	(20)	20	<10		(55)
		Phaco	11		3		86
	6–20	DTA	(10)	10	10		(70)
		Phaco	3	3	3		91
118	<2	DTA	(15)	75	2–5		(5)
	2–6	DTA	(10)	25	20		(45)
		Phaco	30		8		62
	6–20	DTA	(5)	15	40		(40)
		Phaco	6	4	35		55
119	<2	DTA	(25)	50	<5	+	(20)
	2–6	DTA	(30)	20	<10	<2	(40)
		Phaco	31		10	59	
	6–20	DTA	(20)	10	20	25	(30)
		Phaco	17	11	16	22	34

N. B. The values within brackets have been estimated from X-ray diagrams.

The strongly compact portion of sp. no. 117 could not be treated for mechanical analysis. This portion has qualitatively the same mineralogical composition as the non-compact portion. But the latter prominently shows a very high proportion of calcite (50%). Microscopic study shows that calcite is crystallised in veins and preferably around the pisoliths. At places the calcite veins appear to force apart the quartz grains and pisoliths. Hence calcite has resulted from crystallisation of solutions which have migrated through the profile only after the formation of laterite. The preferential crystallisation of calcite around the pisoliths may be ascribed to the local pH conditions.

Sp. no. 118. Mechanical analysis of sp. no. 118 shows that 60% of the specimen is made up of the fine clay fraction whose main constituent is kaolinite. The second maximum lies at the fraction 0·06-0·2 mm. ϕ. It might be due to quartz. The grains of quartz hardly show any corrosion. Distribution of quartz in the sand fractions clearly indicates that the material of the specimen has been derived from a sandstone-like rock as sp.no.110. Pisoliths are rare in this specimen. Haematite occurs in the form of small scales. Goethite is absent. Since calcite occurs only in traces, the specimen is not compact. Its high kaolinite content cannot have originated merely from the weathering of muscovite *in situ*.

Sp. no. 119. This specimen was collected from the top of the laterite profile. Mechanical analysis was carried out on the non-compact portion of the specimen. The size frequency distribution of quartz is exactly similar to that of sp. no. 113. The fine clay fraction is less than in sp. no. 118. In the sand fraction, a maximum at 0·6-2 mm ϕ is produced by calcite. In this case calcite occurs essentially as a part of the aggregates whose other components, as determined by DTA and X-ray analysis, are kaolinite, quartz, goethite and haematite. Under the microscope one can observe that calcite has been deposited in small clusters and veins. As in sp. no. 117, calcite has crystallised after the formation of laterite.

The more compact portion of the specimen, which could not be subjected to mechanical analysis, showed on DTA and X-ray analysis, a higher content of haematite and goethite.

Mineralogical changes in the profile.

Mechanical analyses of the individual specimens, X-ray and DTA studies and optical examination of the various fractions and of thin sections of the rocks signify the following :

Specimens no. 110-119 represent a rock-profile which has originated *in situ*. This is proved by similarity of heavy mineral components of the specimens and the characteristic size frequency distribution of quartz. The unweathered parent rock of the laterite was a fine-grained, white quartz-mica sandstone which was interbedded with red, haematite-rich sandstone bands. Muscovite of the sandstone weathered into kaolinite and haematite of the red bands of sandstone supplied ferruginous material for the iron minerals of the concretions in the upper parts of the profile. In the course of weathering quartz became corroded.

The changes produced in the mineralogical composition of the individual horizons due to weathering can be best followed in the external form of the minerals and their quantitative distribution in the profile.

Quartz.

Quantitatively the most important constituent of the parent rock is quartz. In the specimens no. 120, 110 and 111 of the parent rock the quartz grains hardly show any trace of corrosion. In these specimens the amount of quartz varies from 50 to 60%.

One notices considerable corrosion of quartz grains in the specimens no. 112, 113, 114, 115, 116 and 117. With the exception of sp. no. 113 all the other specimens contain small amounts of quartz. Above sp. no. 118 the quartz content agains increases so that in sp. no. 119 it reaches the same amount as the parent rock. Only little corrosion of quartz grains is to be seen in both the specimens (no. 118 and 119).

Muscovite and kaolinite.

Muscovite forms the second important constituent of the parent rock. In the case of less weathered specimens (no. 120 and 110) it is concentrated in the the silty and fine sand fractions while in the highly weathered specimen, no. 113, the maximum of muscovite lies in the fine clay fraction. In the other fractions there is a greater concentration of this mineral in the fine clay fraction than in the case of sp. no. 113. The absolute amount of muscovite decreases from sp. no. 110

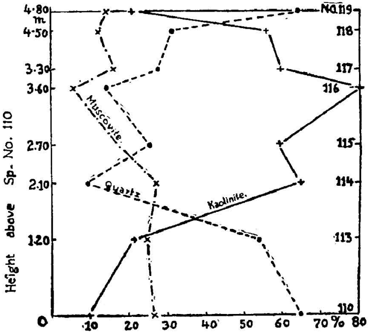

Fig. 12.

Fig. 12. Distribution of minerals in the profile of Pedhamli. (The sum of the three minerals is calculated to 100% in each specimen).

to sp. no. 117 but again increases insignificantly from sp. no. 117 to sp. no. 119 (fig. 12).

Kaolinite has originated from the weathering of muscovite, as is clear from the microscopic study. The amount (by weight) of kaolinite formed as a result of alteration must be equal to the amount of original muscovite.

Muscovite $KAl_2(OH)_2AlSi_3O_{10} = 1/2\ K_2O \times 3\ Al_2O_3 \times 6\ SiO_2 \times 2H_2O$
Kaolinite $Al_2(OH)_4Si_2O_5 = Al_2O_3 \times 2SiO_2 \times 2H_2O$
$K_2O \times 3\ Al_2O_3 \times 6\ SiO_2 \times H_2O + 4H_2O = 3\ (Al_2O_3 \times 2\ SiO_2 \times 2H_2O) + K_2O$
or in molecular weights : $760{\cdot}4 + 72{\cdot}1 = 739{\cdot}3 + 94{\cdot}2$.

If during the alteration, muscovite-kaolinite, no migration of substance takes place, then the sum, muscovite + kaolinite, must be constant in the specimens of the profile. But actually this is not so (table 10). The amount of kaolinite as well as the sum, muscovite + kaolinite, increase considerably from sp. no. 110

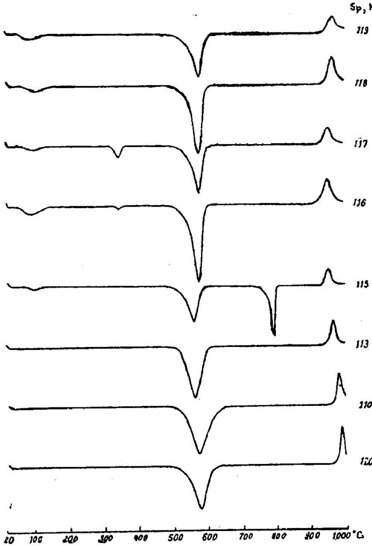

Fig. 13.

Fig. 13. DTA curves of fractions $<2\,\mu\ \phi$ in the profile of Pedhamli.

to sp. no. 116 . From sp. no. 117 to sp. no. 119 there is a remarkable decrease in the amount of kaolinite.

As mentioned above, the amount of muscovite varies inversely with that of kaolinite. From sp. no. 110 to sp. no. 116 the amount of muscovite decreases but again increases slightly from sp. no. 117 to 119. In the specimens no. 113 to 119 a part of the kaolinite must have originated from the weathering of muscovite. No exact reference point is available in order to make a quantitative statement of the muscovite altered to kaolinite, because quartz has been greatly involved in the change-over due to solution. A considerable part of the kaolinic substance of the specimens no. 113-117 must have been added to them. This is shown by fig. 13. One notices a steady transition from kaolinite to the firecalay mineral from sp. no. 110 to sp. no. 117. In the specimens no. 118 and 119 the kaolin mineral is again kaolinite (fig. 13).

In the case of the profile of Eklara, migration of the kaolinic substance could be directly proved. The recrystallisation product of kaolin was the fireclay mineral. Qualitatively similar conditions are met with in the profile of Pedhamli where kaolin has migrated from the lower horizons to the upper. A quantitative estimation of kaolin thus migrated is not possible.

Quartz and muscovite are the residual minerals of the weathering process in the specimens. Kaolinite and iron minerals (apart from the primary haematite of the red sandstone bands) are obviously authigenic minerals. The ratio quartz, muscovite gives an indication of the degree of destruction suffered by these minerals.

In table 10 the values of the sum kaolinite + muscovite and the ratios kaolinite/muscovite and quartz/muscovite for the individual specimens are given. The sum kaolinite + muscovite has been calculated after deducting the amount of iron minerals and calcite. The ratio quartz/muscovite shows in which specimens, due to weathering, quartz or muscovite has been more decomposed as compared to the parent rock (sp. no. 110).

In the case of sp. no. 114, the strong corrosion of the quartz grains is clearly emphasized by the quartz/muscovite ratio. Similarly, in the case of the specimens no. 115 and 117, which come from the same ferruginous horizon as sp. no. 114/ the ratio is less than that of the parent rock. Quartz is considerably corroded in both the specimens and there exists a close relationship between the corrosion of the quartz grains and the amount of iron minerals present in the specimens.

Quartz grains of sp. no. 116 show, under the microscope, very little corrosion. Since the ratio quartz/muscovite is equal to that of the unaltered parent rock, muscovite has not undergone considerable weathering. Hence the high kaolinite content of the specimen has resulted not from the weathering of muscovite and solution of quartz alone but a large part of it might have been derived by migration from other sources.

This is clear from the table 10. The parent rocks consist of about 60% quartz and 40% muscovite + kaolinite. Sp. no. 116 shows 14% quartz and 86% muscovite + kaolinite. Let it be assumed that kaolinite has originated in situ

from muscovite. Since in this case there is no loss of material (see above), the doubling of the amount of kaolinite + muscovite in sp. no. 116, in comparison with that of the parent rock might be due to solution of quartz. The ratio quartz/muscovite (table 10) of sp. no. 116 has remained more or less equal to that of the parent rock. Therefore, muscovite must have weathered in the same proportion as quartz which is reduced to 1/4 of its original amount. The same holds good for muscovite. The ratio kaolinite/muscovite of the parent rock (sp. no. 110) is about 0·4.

Table 10

Sp. no.		Kaolinite + Muscovite %	Kaolinite/ Muscovite	Quartz/ Muscovite
119	Superficial crust	35	1.45	4.6
118	Sandy soil	70	2.7	2.6
117	Spotted soil	75	3.8	1.7
116	Spotted soil	86	14.6	2.6
115	Concretion	75	3.4	1.5
114	Concretion	73	2.2	0.14
113	Soft sandstone	45	1.17	2.2
110	Parent rock	35	0.36	2.5
120	Sandstone	42	0.75	1.9

If muscovite of sp. no. 116, like quartz, were reduced to 1/4 of its original amount and in its place an equivalent amount of kaolinite were formed, then one would expect a kaolinite/muscovite ratio of 5/1. But the actual ratio is 14·6/1. Hence a considerable amount of the kaolinic substance of sp. no. 116 has been added to it.

Table 10 also shows that the quartz content and the sum, muscovite + kaolinite, of sp. no. 119 are equal to the corresponding values of sp. no. 110. Only in sp. no. 119 more muscovite has altered to kaolinite. Hence it is clear that sp. no. 119 is a sandstone similar to the parent rock and that it has been cemented to a hard rock by means of iron compounds and calcite derived from other sources.

Sp. no. 118 has undergone little weathering like sp. no. 116. The excess of kaolin of the specimen is due to addition of the kaolinic substance. An addition of the material is also indicated by the haematite content as it occurs in larger amounts than in the parent rock (sp. no. 110). The kaolin mineral of sp. no. 118 and 119 is kaolinite. This is in sharp contrast with the fireclay mineral of sp. no. 117.

The excess of the kaolinic substance of the upper parts of the profile has migrated from the basal part of the laterite profile (sp. no. 110). The amount of the substance which was carried in solution and later recrystallised cannot be estimated.

The source of the extra kaolin can be traced to the sandstone (sp. no. 110) which lies at the base of the profile. This specimen shows, like the other specimens, the presence of diaspore which indicates that aluminium bearing solutions were present in the profile. On the other hand, diaspore is absent from the sandstone (sp. no. 120). In this case the ratio, kaolinite/muscovite, is double of the corresponding value of sp. no. 110 (table 10). It can be concluded from this that kaolinite has been carried away in solution from the sandstone. sp. no. 110. If one presumes that the degree of kaolinisation of muscovite was equal in both the sandstones and that no kaolinite has been lost from sp.no. 120, then nearly half of the original amount of kaolinite of sp. no. 110 might have been carried away in solution.

Migration of iron in the profile

The development of the laterite profile is largely due to the migration of iron and its subsequent recrystallisation in definite horizons. Fig. 14 shows two horizons which are highly enriched in iron minerals. One of the horizons is represented by the specimens no. 114 and 115 and the other by sp. no. 117.

In the specimens no. 114 and 115, quartz grains are highly corroded and in their cracks haematite and goethite have crystallised. Hence the alkaline solutions, which have corroded the quartz grains, have also brought about the recrystallisation of iron. After its formation, the concretion horizon was permeated by solutions as indicated by the scoriaceous and porosy nature of the specimens no. 114 and 115 and by the crystallisation of the fireclay mineral. It is difficult to prove if haematite has been secondarily removed by solutions.

In sp. no. 117, iron minerals have crystallised mostly in pisoliths. Addition of iron took place from the lower parts of the profile, either from the concretion-horizon or from the bands of the red sandstone.

There exists a sharp contrast between the specimens no. 117 and 118. It is shown by the presence of the fireclay mineral (in sp. no. 117) and of kaolinite (in sp. no. 118) and by the absence of pisoliths and goethite from sp. no. 118. Besides, quartz grains of sp. no. 117 are more strongly corroded. An explanation of these observations is that the ground water-table might have at times crossed the horizon of sp. no. 117 whereas the horizons of the specimens no. 118 and 119 have remained above the water-table and consequently have been comparatively dry. It is for this reason that these horizons contain the iron mineral, haematite. Only in sp. no. 119 some goethite is present.

Origin of the laterite profile of Pedhamli

From the foregoing observations, various stages of the development of the laterite profile can be recognised :—

(a) The laterite has developed from the weathering of the Cretaceous sandstone. During the process of weathering, muscovite has altered to kaolinite and haematite has been removed in solution from the red bands of the sandstone (sp. no. 112 and 113). Iron thus carried away in solution has been redeposited

in the upper parts of the profile (sp. no. 114 and 115.). The strong corrosion of quartz in the specimens no. 114 and 115 and deposition of haematite in the cracks of the corroded quartz grains indicate that deposition of iron was preceded by an attack of quartz of this horizon by alkaline solutions.

(b) After the formation of the concretion zone represented by the specimens no. 114 and 115, kaolinite went into solution in the underlying sandstone (sp. no. 110). The solution of kaolinite can be attributed to alkaline solutions, as was proved in the case of the profile of Kot. From the solutions ascending in the profile, fireclay mineral precipitated. The maximum of precipitation reached above the concretion zone, in sp. no. 116. Fireclay partly precipitated earlier in the concretion zone as well.

(c) Migration of the kaolinic substance was followed by solution of iron in the concretion horizon or in the underlying sandstone (sp. no. 112). In the specimens no. 116 and 117, particularly in the latter, iron minerals were deposited along with the fireclay mineral. The deposition took place partly in the form of pisoliths.

During the migration of materials which led to the formation of the fireclay mineral and pisoliths, the ground water-table had sometime stood at the level of sp. no. 117. The horizons of the specimens no. 118 and 119 have remained above the level of the water-table. Therefore, they contain kaolinite instead of fireclay and no pisolith. Being very close to the surface, these horizons were exposed to desiccation and consequently they contain almost exclusively haematite as the iron mineral.

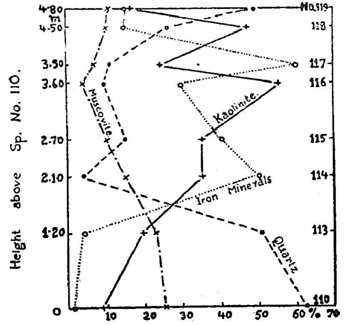

Fig. 14.

Fig. 14. Distribution of minerals in the profile of Pedhamli.

The rising of the water-table upto the horizon of sp. no. 117 can be explained by the depositional action of Sabarmati on account of which the hillock of the Cretaceous sandstone was covered by the fluviatile sands.

(d) The last change, which the laterite profile has experienced, is the migration of calcite which took place after the establishment of the profile or even after the covering of the hillock by the Sabarmati sands. The source of calcite lay most probably in the calcareous sands of Sabarmati. This mineral is especially abundant in the superficial horizon (sp. no. 119) and is rare in other horizons.

The origin of the haematite-rich superficial crust (sp. no. 119) cannot be clearly explained. This crust must have been present before the formation of the pisolithic horizon and migration of the kaolinic material. The pisolithic horizon seems to have cut off connection of the horizons (sp. no. 118 and 119) with the remaining part of the profile. Migration of kaolin has obliterated the traces of the older processes in the lateritic profile. Probably the origin of the superficial crust took place before the formation of the concretion horizon.

The development of the concretion horizon and the pisolithic horizon seems to be connected with the fluctuation of the ground water-table. Thus the cause could be found in the alternating erosional and depositional activity of Sabarmati.

GENERAL CONSIDERATIONS ABOUT LATERITES

Laterites are essentially rocks made up of products of weathering. They originate from the weathering of iron and aluminium bearing rocks under conditions of tropical climate.

The most important components involved in the formation of laterite are iron, aluminium and silica which occur together in the primary minerals of the parent rocks. Lateritic weathering results in a separation, particularly of iron and aluminium, which form their own minerals. Due to different conditions of solution and precipitation, often there occurs a local separation also of the new minerals of iron and aluminium (V. A. EYLES).

In the case of weathering of acid rocks, separation is brought about principally by binding of aluminium in kaolin minerals which are formed in place of the primary minerals and by removal of iron. Oxidic and hydroxidic iron minerals are concentrated in the form of concretions or pisoliths in other parts of the weathering profile. It is on account of this concentration of iron minerals that the development of a typical laterite profile is brought about.

It is still disputable whether the kaolin minerals are end-products of laterite formation or they are further decomposed into silica and aluminium hydroxide. According to numerous observations, during lateritic weathering kaolinic clays originate from the decomposition of granitic rocks. The formation of aluminium hydroxide in such clays is attributed by several workers (ALLEN, VAN BEMMELEN CAMPBELL, EYLES, FOX, HARRASSOWITZ, MEAD, SHERMAN, TER MEULEN) to the breakdown of the kaolin mineral. On the other hand, WAEGEMANS holds kaolin as the stable end-product of lateritic weathering. According to the observations of

some investigators (ALEXANDER, BAUER, HARRISON, LACROIX), plagioclases and other silica-poor minerals give rise to hydrargillite as the primary product of decomposition. Other workers (HARDY, GOLDMAN) hold the view that hydrargillite can be converted secondarily into kaolinite by addition of silica.

The numerous and partly contradictory results of investigations only show that during the formation of laterite more complicated processes might be involved than are generally thought to be. In the present work, solution of kaolinite in one zone and authigenic formation of the fireclay mineral in another has been proved. This shows that the so called end-products of laterite formation are by no means very stable.

In place of or next in importance to kaolinic clay minerals, the following hydroxides of aluminium have been reported from laterities : Hydrargillite [$\gamma - Al(OH)_3$], boehmite ($\gamma - AlOOH$) and diaspore ($\alpha - AlOOH$).

Hydrargillite and boehmite are generally formed by ageing of aluminium hydroxide gels. At a temperature of about 0°C, an amorphous gel precipitates out from a solution of aluminium salts; this gel is converted into boehmite on prolonged standing in cold water (Havestadt and Fricke). Further ageing of the gel in cold water leads to the formation of bayerite (Havestadt and Fricke, Boehm). On shaking with alkaline solutions at temperatures betweens 30 and 60°C one can notice a spontaneous conversion of bayerite [$\gamma - Al(OH)_3$] into hydrargillite [Fricke (1)]. Bayerite has not been found to occur in nature. According to Fricke (2), hydrargillite can be formed directly by very slow precipitation of aluminium hydroxide from alkaline solutions.

According to De Lapparent (1), (2), the presence of diaspore is typical of slightly metamorphosed rocks. Rustrum Roy and E. F. Osborn are of opinion that diaspore is formed under a pressure of more than 140 kg/cm^2 and at a temperature range of 275-400° C. The occurrence of diaspore in the present profiles is, however, not due to metamorphism of rocks.

The following iron minerals have been observed in laterites :— Haematite, hydrohaematite (turgite), goethite and yellow iron hydroxide gel which is usually known as limonite. Hydrohaematite is an oxyhydroxide which is distinguished from haematite by a variable water content. X-ray diagrams of hydrohaematite and haematite are exactly similar. Limonite is mostly opaque to X-rays but sometimes it shows a broad interference of goethite.

Regarding the genesis of these minerals, it can be said that they originate by ageing of iron (III) hydroxide gels. The paragenesis of the four iron minerals can be explained by laboratory experiments. According to Huettig and coworkers, the amorphous iron hydroxide, which originates by the precipitation of iron (III) salts with ammonia or alkaline solutions, is converted under normal conditions after a long ageing process into hydrohaematite. Under different pH and reaction conditions, the ageing process can lead to the development of limonite and goethite. $\alpha - FeOOH$ can be easily produced from fresh oxyhydroxide of

iron precipitated from cold solutions. Prolonged standing of oxyhydroxide of iron can give rise to a mixture of $\alpha-Fe_2O_3$ and [α – FeOOH (Fricke and Ackermann).] Therefore, at normal temperature, haematite ($\alpha-Fe_2O_3$), goethite (α – FeOOH) and limonite can originate side by side from ageing of iron (III) hydroxide gels.

According to Mackenzie, oxyhydroxides of iron prepared in cold solutions give a characteristic reaction with DTA. Similar DTA reactions particularly an endotherm between 300 and 350° C and an exotherm between 350 and 400°C are shown by some of those iron compounds of clays and laterites which are opaque to X-rays.

The large number of contradictory views and theories about the origin of laterites is partly due to the fact that normal petrographic methods are insufficient for the study of these rocks. The essential minerals of laterites and the new minerals formed as a result of weathering are mostly of submicroscopic size. Therefore, a study of thin sections can hardly enable one to recognise fully the mode of origin of the material. Chemical analysis certainly brings out the composition of a specimen but not the mode of its origin. In view of this, the present work should be treated as an attempt to get an insight into the course of development of lateritic profiles by applying the latest techniques of clay mineralogy.

SUMMARY

Two Indian lateritic profiles have been studied. Those specimens of laterite, which were not compact, were subjected to mechanical analysis. Quantitative determination of minerals was made by X-ray analysis, differential thermal analysis and optical methods. Changes in the composition and distribution of minerals were followed in the profiles.

The laterite profiles have originated from quartz bearing rocks—a coarse-grained granite in one case and a fine-grained quartz-mica sandstone in the other The cause of the laterite formation in both the profiles can be found in the weathering and kaolinisation of the parent rock. In the case of the granite, feldspars, biotite and hornblende and in the case of the sandstone, muscovite have been kao-. linised. Quartz has been more or less corroded.

By the enrichment of oxidic and hydroxidic iron minerals in certain zones of the weathering profiles, typical lateritic profiles with concretion bearing and pisolithic horizons have developed. Enrichment of iron in these horizons is attributed to the addition of the element from migrating solutions. In the first profile, iron came from the decomposing mafic minerals of the granite i. e., hornblende and biotite. In the second profile, the source of iron has been traced to the haematite-rich bands of the sandstone. Of the hydroxidic minerals of aluminium only diaspore is present in small amounts.

Solution of kaolinite, migration of the kaolinic material and authigenic formation of the fireclay mineral have beeen proved in both the profiles.

BOOK REVIEWS

The Origin of Man and His Culture : by Stephen Fuchs, Asia Publishing House, Bombay, 1963, pp. 300, Rs. 12·50.

There is a great dearth of good text-books in India, written by competent authors. A book like the present one is greatly welcome The book is not without its defects, but it is very difficult to present everything important under two hard covers. It is an unpalatable truth as the author himself speaks out in the Preface that the Indian students know more about the foreign cultures than about their own. This is an obvious fact, since the text-books so far have been written by foreign scholars giving examples from the foreign cultures. Comparatively, there has been less data-collection in India, and whatever little data we have of our culture needs careful classification and complilation. In such context, any text-book dealing with Indian data is most welcome, and especially so when it comes from a competent author like STEPHEN FUCHS.

The author himself has been apologetic for treating the Indian material so sketchily, and rightly so, for as he says, the Indian material has not been previously treated in a systematic and comprehensive study and that the limitations of space come in the way of more generous treatment of vast and complicated material.

This book has been written from a traditional anthropological angle. It has treated anthropology as a historical science as against the modern method of dealing the data exclusively from the structural-functinal stand-point.

Primitive cultures have been classified into four types–in order to under–stand the origin and their subsequent historical sequence-the foodgatherers,the advanced hunters, the primitive cultivators and the nomadic animal-breeders. The author has also tried to explore the original sources of Hindu Culture. The book deals with the origin of art, not only with painting and sculpture, but also with poetry, dramatic art, dancing and music.

Inclusion of the Indian material has not affected the proper discussion of the theory of anthropology. The theory has been discussed without any specific bias, the approach which is very essential for the students to know the various points of view. Adequate examples from foreign cultures have also been given.

One-third of the book is devoted to dealing with Physical Anthropology. All the aspects of Physical Anthropology—origin of man and races, contemporary human races and prehistory have been discussed. Racial strains in India have been dealt with keeping in view the various view-points. The portion dealing with Physical Anthropology has been followed by Cultural Anthropology, starting with Primitive Family.

The author has tried to give too much in one book and yet has successfully kept the number of pages under control. This has naturally resulted in a rather cursary discussion of some of the important topics. It would not have been out

of tune if 'The Indian Caste System' was not discussed. Dismissing such an important topic summarily appears very queer. Similarly, the topic on ' Association ' and Class ' has not been given due importance inspite of the fact that systematised data is available on this topic with regard to India.

The approach of the book has been clearly formulated in the Preface and eminently summarised and concluded in the Epilogue. The anthropological angle of cultural relativism to primitive societies, that they are neither noble savages nor barbarians but people like us having different cultures has been clearly stated in the Epilogue.

Chapterwise bibliography at the end is worth mentioning and can give further clues to hard-working students. However, it may be difficult for an average Indian student to understand the book as it is. Too much material has been stuffed in three hundred pages. It is an excellent book if teaching is done properly from the text book and if the teachers elaborate it thoroughly. It would be better still if the book be divided into two separate volumes - Physical and Cultural. No adverse remarks belittle the significance of the book. The book deserves to be translated in various Indian languages.

— R. K. MUTATKAR.

Environment of early man with special reference to tropical regions, By Frederick E. Zeuner (The Maharaja Sayajirao Memorial Lectures— 1960-61) Maharaja Sayajirao University of Baroda, Baroda 1963. pp. 1-31, Rs. 3·50.

A tragic and posthumous interest attaches to this book. Before the book reached the author in London, he died, practically in harness. Prof. ZEUNER delivered his last lecture on 5th November at 6 p.m. at the Institute of Archaeology in London. Soon after he had an engagement at the B.B.C., but this never came off. All of a sudden he collapsed. And thus the archaeological world has indeed become poorer. Discoveries in various fields will be made, no doubt. But without ZEUNER's magic touch they will remain wooden or dead, nothing but objects of stone, wood or clay. Over the years by combining a knowledge of of various disciplines — physics, chemistry, geology, entomology, solar radiation, eustatic fluctuations and the latest — radiocarbon-methods — ZEUNER had devised means by which the soil and stone could speak and reveal their secret to the archaeologist. Thus in his hands objects long since dead were once again brought to life, as it were. It is this fascinating story that ZEUNER has told us in the three lectures that he delivered at Baroda in 1960.

In a very short compass ZEUNER points out first how things are being studied in their totality now, instead of in isolation, whether it be plant, animal or man. Thus in all these subjects no one is interested in simple classification. What one wants to know is not only the class of plant, animal or man, but its or his reaction to climate, vegetation and other surroundings. This is expressed by one word " environment ". And present-day archaeology — particularly prehistoric— is primarily interested in the study of man's changing attitude to his environment. ZEUNER illustrates by taking typical examples how man has strove to become independent of his natural environment. And incidentally he discusses briefly who can best tackle this problem ! He is of the opinion that best results can be obtained if a knowledge of several scientific disciplines, including archaeology, is combined in one person. But this is a view with which scholars like Dr. BRAIDWOOD are not in agreement. The latter would rather take out a team of experts — geologist, climatologist, chemist — say to Iraqi Kurdistan — rather than entrust all the work to a scholar like ZEUNER.

Even a study of stone tools over the millennia reveals how man has tried to adapt himself to his changing environment. What is a tool ? It is nothing but a deliberate, purposeful thinking on the part of man devising means to serve a particular need. Examined from this point of view, the so-called handaxes and cleavers found in early deposits in Asia, Africa and Europe not only indicate that man had to contend with a kind of environment in which food had to be dug up from the earth in the form of roots and tubers, and a way made through some kind of forest by cutting trees and/or cut up animals which were trapped by various

devices. ZEUNER thinks that though a cleaver was a good cutting tool it was in no way more efficient than a simple large flake. And it was more out of aesthetic consideration that a cleaver (and even the handaxe) came to be made. This view does not seem to be quite correct or take into consideration all the aspects of cleavers and handaxes. While many handaxes and some cleavers are a thing of beauty and thus would be regarded as objects of art, still the main reason they came to be made seems to be that they could be much more conveniently handled than flakes whereas some of them were or could have been hafted.

ZEUNER's other remark that the Nevasian type of tools, like the Clactonian, in which scrapers and borers occur prominently implies the presence of an elaborate industry in wood or other perishable material, deserves to be noted. He cites in this connection the Clactonian spear of Great Interglacial Age, now in the British Museum (Natural History). The Nevasian is also remarkable for the occurrence of incipient tanged tools, that is, tools with handles. This might have enabled man, as elsewhere, as ZEUNER has pointed out, to penetrate regions where raw material was scarce.

More than the tools, it is the soils and the sediments in the sea, river or lake that enable the experts to say something more definite regarding the past climatic conditions, during which man lived as a food-gatherer. ZEUNER first draws our attention to what are called " pluvials " or periods of heavy rains. He tells us after a brief review of the present state of studies that the chronological connection between humid-temporal phase of the Mediterranean and glacial phase of northern Europe is well established, as far as the Upper Pleistocene is concerned but that of the dry belt of Africa and Sahara has to be reviewed in a slightly different way. In the latter, Sahara, the absolute intensity of the pluvial was slight, though it had experienced humidity repeatedly, but in the former a number of factors such as level of water in lakes and in the rivers which feed them has to be considered. While discussing the problem of pluvials in the tropical rain belt in Africa, ZEUNER makes a few pertinent remarks which are quite relevant to conditions in India He says that the mere presence of river pebbles in a river does not justify the inference of a humid phase—past or present — in a region. It depends upon in what surroundings — environment — one finds them. In semi-arid areas these gravels are transported by seasonal floods and thus are not indicative of a humid phase, whereas upstream in the same river they may exist because of steeper gradient.

Speaking directly on climatic conditions in India in the past and the part played by man therein, one can very briefly state his broad conclusions. Correlating his observations in Gujarat, Orissa and Madras, ZEUNER categorically rules out the general pluvial hypothesis, as it is suspected even in Africa. That is, there was no such thing " as a phase of tropical rains contemporary with a glaciation of the northern hemisphere ".

He further postulates the following climatic sequence and the development of Stone Age industries :

1.	Pre-laterite indicating a drier phase at Vadamadurai, that is on the S. E. Coast or Madras.	Early Abbevillio-Acheulian industry.
2.	Period of heavy rain, and formation of laterite (intensive red weathering) on the S. E. Coast.	Acheulian Industry.
3.	Extension of this climatic phase to Gujarat and Orissa, causing *rotlehm* weathering or formation of red soil	
4	Withdrawal of the wet climatic phase from Gujarat.	Middle Acheulian Industry.
5	Extension of desert belt in south-eastern direction, into the Indian Peninsula	

ZEUNER from his (brief) observations thought that the gravels on the Sabarmati were not divisible and so also the contained Stone Age industry which was mainly Acheulian. Very recent observation of the section at Hirpura by the writer showed that blue or mottled clay is intercalated with the gravels at least twice, if not more. In fact, the situation reminds us of the section on the Rihand (Rewah State) illustrated by ZEUNER (Fig 24), where there is cemented gravel between layers of mottled clay. If this observation is correct, then it means that the gravels were deposited twice or thrice, and in between the mottled clay formation took place. Here, therefore, if the various gravel horizons are carefully searched, a development in the Stone Age industry might be witnessed.

With regard to the formation of the silts of northern Gujarat, ZEUNER is convinced of their wind borne origin, and says that they must have come from the deserts of the dry belt further west. Hence the Upper Pleistocence in Gujarat is said to be represented by an arid phase instead of by a pluvial.

It may be said that similar conditions prevailed further eastwards and as demonstrated by deposits of fine gravels in all the Peninsular rivers southwards, but its intensity was much less.

Concluding this part of his lecture, ZEUNER refers to the problem he had in hand, viz. the testing of the likely relationship in time between the southward extension of the dry belt and the last Mediterranean pluvial. And he puts forward a very suggestive equation :

Northern Glaciation = Mediterranean Pluvial =

Southern dry belt = Low sea level

and evidence of dry conditions below sea levels in Gujarat rivers, down stream or southern Dry Belt = Interglacial = High sea level.

This is not pure climatology, but an attempt at understanding the problem from a wider view point. This will not only give a relative time sequence, but also help to know the conditions under which man lived in the past.

Unfortunately, before ZEUNER could arrive at any definite conclusion he died.

Lecture III is devoted to the discussion of the study of environment by studying flora and fauna. Ordinarily it is too well known that wood and trees are and have been used by man for various purposes, though it is not common knowledge that bones of whales were employed for making huts in the high North, as were those of the mammoth during the Upper Palaeolithic in periglacial Europe.

Now a study of the fossil fauna or flora informs us about the natural conditions obtaining in the countryside at the time of man's occupation. This is illustrated by a few chosen examples. Fauna useful to archaeologists is not confined to mammals, but as ZEUNER says it should include mollusca and even insects. And if a close watch is kept of the chronological relationship of these remains to the archaeological layer under investigation, much can be learnt.

Thus, as ZEUNER tells us, the discovery of Middle Stone Age tools in the skull of a *Bos namadicus* Lydekkar at Kalegaon on the Pravara conclusively proves that Middle Stone Age Man was responsible for its death.

Again the study of the animal remains from Langhnaj shows that man must have been a hunter, for no domesticated specimen occurs. But of all these the discovery of deliberate pits on a rhinoceros shoulder blade was very interesting, for it proved that the shoulder blade was used as an anvil by microlithic man of Gujarat.

But about the climatic interpretation from the presence of rhinoceros ZEUNER has to give a slightly different interpretation than before. He no longer thinks that the climate was more wet at the time when man lived. It was relatively dry and could support only a thin vegetation. Therefore animals like rhincoeros were confined to the river valleys and their nalas, both in Sind and Gujarat. While discussing the rhinoceros, ZEUNER describes in detail how by a study of the forms of the skull, the mode of life of the rhinoceros and its environment can be inferred. Thus forest rhinoceros carry their head more or less horizontally, those of the steppe the head is inclined and those of the grassland is strongly inclined, and the skull is constructed accordingly. Thus except man, animal species changed according to climatic and environmental requirements. As an illustration of the usefulness of insect study, Zeuner cites grashopper from the Upper Pleistocenne of Saturnia, a place in the Carpathian mountains. Their intensive study have enabled scholars to determine the average temperatures of the summer months during the glacial phase in question.

This rather lengthy review of a small book—just 32 pages—would bring home to us all interested in environmental archaeology and its manifold approach, what a serious loss the archaeologists the world over, and particularly those in India have suffered, by the sudden death of Prof. ZEUNER.

H. D. SANKALIA

OFFICE OF THE DIRECTOR OF ARCHAEOLOGY
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INDEX

ANSARI Z. D.

A Potter At Work.

BDCRI, 24, 1-14.

The paper presents an account of modern techniques of pot-making from primary stages of the preparation of clay to the final ones of decoration like burnishing and painting. The tools used for these processes at present are described. Since most of the shapes and decorations of modern earthern pots could be found in the pottery of the earlier periods, the discussion of modern methods would be of interest to students of archaeology in general and ancient ceramics in particular.

DHAVALIKAR M. K.

The Origin of Tara.

BDCRI, 24, 15-20.

The Buddhist goddess Tara, the deity of navigation, has been said to be essentially of Buddhist origin and is said to have originated somewhere around Laddakh whence she was introduced in India. The writer, after examining the literary and sculptural evidence shows that she was originally a Hindu deity, later on borrowed by the Buddhists. Further, it has been shown that her concept originated in Western India and thence spread in other parts of the country and beyond the frontiers of India as well.

JAMKHEDKAR A. P.

and

NAGARAJ RAO M. S.

The Sapta Nagas of Devgeri.

BDCRI, 24, 26-27.

In the courtyard of the Mallikarjuna temple at Devgeri, (Dist. Dharwar) a large sculptured stone panel (7′ × 19′) is found. It has seven figures with human heads and coiled serpent bodies. (One figure is slightly damaged.) The paper shows that the seven figures are those of the saptanagas, Vasuki, Taksaka, Karkota, Padma, Mahapadma, Sankhapala, and Kulika; it assigns 12th-13th centuries A.D. as the probable date.

JOSHI R. V.

Excavations in the Pre-Historic Cave Sites in France.

BDCRI, 24, 21-25.

Of all the countries in the world, France has the maximum number of well-preserved prehistoric sites, which makes it a classic region for prehistoric studies, especially for the paleolithic cultures. A peculiarity of these are the caves bearing the remains of prehistoric man. The technique of excavations of these sites is a greatly developed art in that country; this paper describes the means and methods adopted by the French excavators of this decade.

KAMAT A. R.

How Many Letters Does One Receive ?

BDCRI, 24, 58-70.

The present article is an attempt to study one aspect of personal correspondence (letters and other written forms of communications, by post or by hand), received by a person. The person selected for this case-study is a fairly senior member of the teaching staff of an old and reputed college in Poona. By its very nature, the correspondence is of a highly individual character. Even so this study is presented here in the belief that it may throw some light on the structural character of personal correspondence of individuals belonging to a small but socially important group of intellectuals in our society.

KARVE-CORVINUS G.

and

KENNEDY K. A. R.

Preliminary Report on Langhanaj : 1963.

BDCRI, 24, 44-57.

This is a preliminary report on the archaeological excavations at Langhanaj (North Gujarat) conducted by the authors during November-December 1963. The conclusions are tentative, based on field-observations and are subject to modifications through laboratory studies of the antiquities obtained. The discovery of copper during these excavations necessitates a re-examination of the chronological position of Langhanaj. The dig also makes it necessary to revise the earlier interpretations in the field of geological (soil) analysis and anthropological data.

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KENNEDY K. A. R.

and

RAJGURU S. N.

Skeletal Evidence for Pleistocene Man in India.

BDCRI, 24, 71-76.

In 1962-63, three semi-fossilized jaws, two human and one sheep, were found in association with Pleistocene deposits of river Mula-Mutha near Bund Garden, Poona. The detailed study of these jaws proved them to be of recent origin and they appeared to be intrusions into the earlier deposits. In the light of these discoveries, a review of the other cases of the association of human bones with Pleistocene deposits in India has been taken.

KHARKWAL A. D.

Contribution to the knowledge of Indian Laterites.

BDCRI, 24, 77-119.

(Translation of the paper : *Beitrag Zur Kenntnis Indisher Laterite* by KOESTER H. M.)

Two Indian lateritic profiles, one at Kot and the other at Pedhamali in the Sabarmati area (Gujarat), have been studied. Those specimens of laterite, which were not compact were subjected to mechanical analysis. Quantitative determination of minerals was made by X-ray analysis, differential thermal analysis and optical methods. Changes in the composition and distribution of minerals were followed in the profiles. The paper presents the results of these studies.

Mate M. S.

Downfall of the Marathas.

BDCRI, 24, 31-35.

The paper seeks to place proper emphasis on Imperialism (as a world movement) in the analysis on the causes of the downfall of the Maratha power. Such a clear restatement is necessitated because even the latest researches dwell on internal factors without taking due note of the various currents of world history prevailing from time to time.

Nagaraj Rao M. S.

and

Jamkhedkar A. P.

The Sapta Nagas of Devgeri.

BDCRI, 24, 29-27.

In the courtyard of the Mallikarjuna temple at Devgeri (Dist. Dharwar), a large sculptured stone panel (7′ × 19′) is found. It has seven figures with human heads and coiled serpent bodies. (One is slightly damaged.) The paper shows that the seven figures are those of the sapata nagas, Vasuki, Taksaka, Karkota, Padma, Mahapadma, Sankhapala and Kulika; it assigns 12th-13th centuries A.D. as the probable date.

Rajguru S. N.

and

Kennedy K. A. R.

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REDDY P. H.

Family Position and Higher Education.

BDCRI, 24, 36-43.

The paper presents the hypothesis that the educational achievement of an individual in Hindu society and the type of education which he receives, depend on the position of his family—social, economic and educational.

SHARMA P. R.

Vishnu image in 'Vishvarupa' (Nepal).

BDCRI, 24, 28-30.

The paper discusses an image of Vishnu from Bhaktapur in the Vagmati Valley (Nepal). The image is a depiction of the Vishvarupa form of Vishnu. It belongs to the Classical period of Nepalese sculpture and could be dated to the latter half of the eighth century A.D.

OFFICE OF THE DIRECTOR OF [illegible] OLOGY
26 AUG 1969
GOVT. OF MADRAS, [illegible]

FORM OF DECLARATION

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9. Editor's name Nationality Address	Dr. N. G. Kalelkar. Indian. Deccan College, Poona—6.
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(b) an existing newspaper,	An existing newspaper.
(c) in case the declaration falls under item (b) the reason for filing the fresh declara-	The Bulletin has not hitherto been published regularly but at irregular intervals, although it is published as a series with continuous volme Nos. It is now proposed to published it as a Quarterly.

Date : 27-2-1964.

Signature Sd. (S. M. Katre)

NAME (IN BLOCK LETTERS) S. M. KATRE

DESIGNATION Director, Deccan College Postgraduate & Research Institute, Poona—6.